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A REVISION OF THE GENERA OF ARTICULATED CORALLINES

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TWENTY PLATES

The articulated corallines, a group of red algæ (Rhodophyceæ), belong to the more highly organized Florideæ. Kylin,(15) in his first treatment, includes Corallinaceæ under the order Cryptonemiales. This order is characterized by the presence of typical auxiliary cells which are arranged in specialized filaments and differentiated prior to fertilization. In the different families of the Cryptonemiales the reproductive system varies in structure and distribution. In the Corallinaceæ the carpogonial branches and auxiliary filaments are assembled in differentiated nemathecia on the surface of the frond and enclosed by peritheciumlike protective coverings, in this group usually called conceptacles. Corallinaceæ is divided into two sections, Corallineæ and Nulliporeæ;(11) Corallineæ and Melobesieæ(13, p. 259) are distinguishable by the presence of segmented or jointed erect fronds in the Corallineæ and their absence in the Nulliporeæ or Melobesieæ. The segmentations are made up of the alternation of uncalcified with calcified segments, respectively called genicula and intergenicula. The alternating segments likewise differ in structure in various degrees in different genera and different species. The erect fronds of the articulated corallines seem to arise always from crusts or horizontal thalli, like in some species of Melobesieæ. The erect articulated fronds

arising from these crusts are branched in various ways, and the segments are of different shapes. The reproductive organs have been found only on the segmented fronds. There are three kinds of reproductive bodies known in Corallineæ; namely, tetrasporangia, cystocarps, and antheridia, each of which is borne in a special receptacle or conceptacle. The three corresponding kinds of conceptacles are borne in similar positions on the erect fronds but on different individuals, except in *Jania* (*Jania rubens*) where the cystocarpic and antheridial conceptacles have been found in the same individual.(30, p. 99)

From the foregoing it appears that the positions of the conceptacles, the structure of the genicula and of the intergenicula, the modes of branching, and the shapes of the articuli differ, and the combination of these characters can probably be used to draw lines of generic distinction. These variations will be examined in detail before their relations to generic cleavage are discussed.

MORPHOLOGY

THE CRUSTS

According to available records, the early stages of the development of articulated corallines are crustaceous expansions, or horizontal thalli, designated as "crusts." Harvey seems to be the first to give an account of the crustaceous stage in the articulated corallines, particularly in *Corallina officinalis* Linn., which he describes as:—"root, a widely spreading calcareous crust."(11, pl. 222) Thuret(30, p. 100) observes that when the spores of *Jania rubens* germinate, hemispherical structures are first developed from which arise the erect segmented fronds. Yendo(37, p. 7) emphatically states that the embryonal stage of the Corallinæ is a mere incrustation upon a substratum, from which arise the erect segmented fronds. Rosenvinge(27) likewise states that the articulated fronds of *Corallina officinalis* are given off from a basal crust, very much like in some crustaceous Lithothamnia. Oltmanns(25, p. 269) emphasizes that in the development of Coralineæ (citing *Jania rubens* as an example) crusts are first developed from which arise the segmented fronds. In the species of *Corallina, Calliarthron,* and *Bossea,* which have been observed under natural conditions on the Pacific Coast, particularly in the Moss Beach region of Central California Coast, the early stages of their development appear as orbicular lobed crusts from which later evolve the erect segmented fronds. The crusts reach a diameter of approximately

2 cm, but in several instances they are of greater diameter. In the latter cases they are made up of two or more crusts fused together, with the fusion margins readily detectable. In *Corallina officinalis*(27) the crust attains a diameter of 2.4 cm.

Our knowledge of the microscopic structure of the crusts is very limited. According to available records, Rosenvinge is the only worker who has made investigations along this line, but he merely described the structure of the crust of a single species, *Corallina officinalis*. The crust is made up of 3 layers: a hypothallus of long cells arranged in a horizontal direction; a perithallus of ascending filaments of shorter cells; and a layer of nondividing cover cells, perhaps in interrupted continuity. Unfortunately a complete account of the crusts of all the species of the articulated corallines is impossible, because the only crusts available are those of species of *Corallina, Calliarthron,* and *Bossea,* on the accessable parts of the California Coast. The crusts in all these genera are likewise made up of three layers, the epidermis, the perithallus, and the hypothallus. The epidermis is a layer of rectangular thick-walled cells, covering the surface of the older portions of the crusts, first appearing several cells from the growing margins in species of *Corallina* and *Bossea,* and one layer or more of the same type of cells in species of *Calliarthron,* likewise covering the older portion of the crust to within several cells from the margin. The epidermis of the crust of the species of *Calliarthron* is a single layer towards the margin and two or more layers on much older portions of the crust. The marginal regions of the crusts of the species concerned are covered by a distinct continuous structureless membrane. These marginal regions are made up of flabellate meristematic tissue differentiated to some extent into a hypothallus and a perithallus. By the growth of the hypothallus and of the perithallus the crust increases both in diameter and in thickness; this development will be taken up more in detail in the near future, when material becomes available, in connection with the study of the comparative anatomy of the crusts of the different species of the articulated corallines.

The hypothallus is made up of several layers of horizontal long-celled filaments which branch radially and in their turn produce filaments that curve upwards and outwards, constituting the perithallus, the cells of which are comparatively very much shorter than those of the hypothallic filaments, and the length of the cells of which gradually decreases towards the periphery.

The filaments and the cells of the hypothallus and of the perithallus are arranged in a fashion similar to that of the intergenicula of the genera and species to which they belong, the structure of the perithallus and of the hypothallus, respectively, resembling the structure of the intergenicular cortex and medulla of their genera and species. In species of *Corallina* and *Bossea*, for example, the hypothallic filaments are straight and parallel, and the cells are to some extent arranged in uniform transverse zones, while in species of *Calliarthron* the filaments are flexuous and interlacing, and relatively very much shorter than those of the species of the other genera. The crust of *Calliarthron*, in addition, is about three or four times as thick as that of the species of *Corallina* and *Bossea*. These structural differences suggest that the structure of the crusts of the other genera (*Amphiroa, Arthrocardia, Jania, Cheilosporum, Metagoniolithon, Pachyarthron,* and *Joculator*) also varies with the corresponding variations of the structure of the intergenicula, a point of inquiry that will be taken up later when sufficient material becomes available for investigation in conjunction with the projected study of the comparative anatomy of the crusts of the different species of the articulated corallines.

In certain species of Melobesieæ the crusts are made up of a distinct hypothallus, perithallus, and epidermis or cover cells arranged in such a way as to resemble the structure of the crusts and of the intergenicula of certain species of the articulated corallines.

The reproductive organs of the more highly developed species of the Melobesieæ are incased in special receptacles (conceptacles) comparable to those of the articulated corallines, and situated in or on their horizontal thalli, or, in certain species, on erect unsegmented protrusions of the horizontal thallus. In the articulated corallines the conceptacles have only been found on special erect protrusions of the horizontal thallus comparable to the Melobesieæ, except that in the articulated corallines the receptacle-bearing structures are segmented into alternating calcified and uncalcified segments respectively designated as intergenicula and genicula. These similarities in the structure of the thallus and of the reproductive organs, and in the localization of the reproductive organs in certain species of the Melobesieæ to those of the articulated corallines, suggest a generic relationship between the Melobesieæ and the articulated corallines, whichever direction evolution may have progressed. In a sense

the articulated corallines may be thought of as species of the Melobesieæ in which the reproductive organs are borne only on the more highly specialized structures, the articulated fronds.

THE GENICULA

The uncalcified segments of the erect fronds were called "geniculа" by Areschoug (3, pp. 529–561) and "nodes" by Weber van-Bosse. (32, pp. 86–101) In this account the term *genicula* will uniformly be used. According to Yendo (37, p. 26) "the formation of the geniculum takes place at an early period of the development of the frond, and the first geniculum is already perceptible when the process of the frond has reached 1 mm above the incrustation." In *Corallina officinalis* (27, p. 270) the articulated fronds are connected with the crusts by the genicula. In species of *Corallina, Calliarthron,* and *Bossea* that have been investigated in this study, the basal genicula are likewise developed in the early stages and are recognizable at the earliest appearance of the erect fronds on the surface of the older portions of the crusts. In the species that have been investigated the basal genicula are the first permanent structures developed. They arise from the hypodermal layer of the perithallus, and their development may be traced as follows: certain cells of the hypodermal layer of the perithallus elongate to a length characteristic of the species; then short segments are marked off at distal ends of the elongated cells. The lower segments become the basal geniculum of the erect frond, and the upper segments become a flabellate meristem which gives rise to succeeding alternating calcified and uncalcified segments (respectively designated as intergenicula and genicula). In the articulated corallines there are two sorts of genicula, the unizonal and the multizonal. The unizonal genicula are represented in certain species of *Amphiroa,* and in all species of *Corallina, Cheilosporum, Duthiea, Arthrocardia, Bossea, Calliarthron, Jania, Joculator, Pachyarthron,* and *Lithothrix,* while the multizonal genicula are characteristic of most species of *Amphiroa* and all the species of *Metagoniolithon.* In *Lithothrix* the genicular cells are several times shorter than those of the intergenicular medullary cells, while in species, with unizonal genicula, the genicular cells are slightly longer than those of the intergenicular medullary cells. Unfortunately the development of only a few species of the latter group has been traced, but it may be that, in the case of multizonal genicula, the genicular primordia un-

dergo transverse division into the number of zones characteristic of the species. According to Yendo (37, p. 28) and Oltmanns (25, pp. 267–271) the primary genicula of the branches develop in a way similar to those of the basal genicula of the main fronds. The basal genicula and the primary genicula are (in the sense of our interpretation) both perithallic in origin and arise very close to the apical meristem of the structure concerned. On the other hand, the secondary genicula are medullary in origin (or hypothallic in our sense) and arise in regions several rows of cells below the growing apex. (37, pp. 26, 27) In the early stages of their development the genicula are not completely differentiated and are still completely corticated. As development progresses, the cells of the genicular primordia elongate and become thick-walled in unizonal genicula, but in the case of the multizonal genicula the cells of the genicular primordia undergo transverse division into the number of zones characteristic of the species. This process is accompanied by cell elongation of the various zones and thickening of the cell walls, a process during which the cortex remains unchanged and consequently is subjected to great pressure by the enlargement of the cells of the inner tissue. At a certain stage, however, the cortex is unable to withstand the internal pressure and consequently is ruptured. In many instances the broken cortex persists unchanged, particularly in species with unizonal genicula, so that the genicula remain uncorticated, while in other instances, particularly in species with multizonal genicula, the inner layers of the disrupted cortex become meristematic and regenerate a cortex which completely envelopes the genicula. The genicula proper, even where they are unizonal, are comparatively much longer than the individual rows of cells of the intergenicular medulla, the only exception being those of the species of *Lithothrix*, in which they are many times shorter than the individual rows of cells of the medulla.

The cells of the genicular tissue are thick-walled, appearing almost polygonal in cross section. (37, p. 18) In species with unizonal genicula (except in *Lithothrix*), the cells have thin-walled tapering ends, referred to as "extragenicular portions" with the sectors between these tapering ends with much thickened walls. The characteristic tapering ends of the genicular cells have not been observed in multizonal genicula and in *Lithothrix*, suggesting that the cells in the development of the multizonal genicula do not undergo so much differentiation. This suggestion is supported by the fact that, in general (except in thickness of the

walls), the cells of the multizonal genicula are closely similar to those of the intergenicular medulla in the same species.

While Yendo(37) definitely describes marked variations in the genicular structure, he seems to ignore the value of such structures in outlining the taxonomy of the articulated corallines. Mme. Weber van-Bosse,(32) on the other hand, emphasizes the fundamental value of such structures in taxonomy. She calls attention to the fact that the genicula of the species of *Amphiroa* and *Metagoniolithon* are multizonal, while those of *Corallina, Jania, Arthrocardia, Lithothrix,* and *Cheilosporum* are unizonal. She further emphasizes the fact that the successive rows of cells of the genicula of *Amphiroa* are unequal in length. From a study of the genicular structure of a very large number of species of the articulated corallines, collected from the Pacific coast of North America, and obtained from herbarium materials from other parts of the world, made available through the courtesy of different European herbaria, there has been found strong indication of the value of the varying structure of the genicula in attempts to make more clear the taxonomy of this group. All the species of *Corallina, Arthrocardia, Calliarthron, Cheilosporum, Pachyarthron, Jania, Bossea, Joculator,* and *Duthiea* have long unizonal genicula; *Lithothrix* has comparatively short unizonal genicula; and most species of *Amphiroa* and all species of *Metagoniolithon* have multizonal genicula of varied structure.

THE INTERGENICULA

In the foregoing pages it has been pointed out that the crusts give rise to erect fronds with regular alternating calcified and uncalcified segments. The calcified segments have been called articuli,(2, 3, 10, 12, 21, 38) joints,(8, 32) and articulations, (16; 17, pp. 266–292) but in this account the term intergenicula will be used consistently.

Like the geniculum, the intergenicular primordium appears as a flabellate structure or rows of flabellate meristematic cells. In *Amphiroa*(32, p. 81) this meristem is covered on the outer surface with cover cells (Deckzellen); in *Metagoniolithon* it is covered with a thick, structureless, cuplike membrane very closely similar in outline, but not in structure, to the root cap of flowering plants; in the other genera this meristem is merely externally covered with a very thin structureless membrane. In the formation of the intergenicula(32, p. 81) the cells of the central portion of the meristem merely divide transversely, forming cells of the medulla, while the cells of the peripheral regions undergo

both transverse and oblique divisions. The cells resulting from the latter divisions are pushed sideways, and by subsequent transverse and longitudinal divisions lateral tissue (cortex) is formed.

After the basal geniculum of the erect frond is formed, the development of the succeeding intergenicula and genicula follows in regular order. The basal intergenicula are always cylindrical, but those of the upper portions of the erect fronds vary in shape in the different genera as well as in the different species, and also in the different portions of the fronds of the same species. In *Jania, Pachyarthron, Metagoniolithon,* and in a number of species of *Amphiroa* the intergenicula are cylindrical or subcylindrical. In *Calliarthron* as a rule most of the intergenicula are compressed, but those of the species with stunted growth have the tendency to be cylindrical, and in other species the branches likewise end in extensions made up of cylindrical intergenicula. The compressed intergenicula vary in form from almost rectangular-oblong and cuneate to obcordate, with lobes obtuse or acute in species of *Amphiroa, Corallina, Cheilosporum, Bossea, Calliarthron,* and *Joculator.* The variations in shape of the intergenicula have been used by a number of authors in their generic and specific distinctions in the taxonomy of the articulated corallines, so that they will be taken up again in connection with the taxonomic account of this group.

According to available literature the internal structure of the intergenicula of a large number of species has been deemed worthy of particular attention. Thuret(30) states that the frond of *Corallina* (citing *C. officinalis* as an example) consists of central filaments the cells of which are long and arranged in zones of equal length, and that the cortical filaments are produced by lateral branching from these central filaments. According to Areschoug(3) and Ardissone(2) the intergenicula are made up of cortical and interior tissue, the cortical tissue consisting of subspherical cells and the interior tissue of ellipsoidal or filiform cells arranged in transverse zones. Yendo in his figures(36) shows that the intergenicula of species of *Amphiroa* are made up of a cortex of almost isodiametric cells, and a medulla of rows of long and rows of short cells alternating in a variable pattern. Weber van-Bosse,(32) in speaking of *Amphiroa,* states that, "the branches whether ascending or spreading horizontally, have all a central strand of elongated cells and a cortical layer of isodiametric or ellipsoidal cells." In a large

number of species of the articulated corallines investigated, the intergenicula are made up of epidermis (or a layer of cover cells), cortex, and medulla. The epidermis is made up of a single layer of rectangular thick-walled cells.

The cortex consists of filaments whose cells decrease in length towards the periphery. These cortical filaments are arranged almost parallel to one another except in *Calliarthron*, where the cortical filaments are flexuous and interlacing. In a considerable number of species of the different genera, the cortical filaments radiate obliquely from the medulla, while in *Pachyarthron*, (*Pachyarthron cretaceum*), *Lithothrix* (*Lithothrix aspergillum*), and in some species of *Amphiroa*, these filaments appear directly perpendicular to the medulla, so that in the latter cases the medulla and the cortex are very distinctly differentiated from one another.

Of the three tissues of the intergenicula, the medulla exhibits a great variety of structural variations in the different genera and in the different species. The medulla of all the species of the different genera investigated is made up of filaments whose cells are arranged in zones or rows. The medulla of *Lithothrix* is merely a single horizontal rows of long cells. In *Calliarthron* the medullary filaments are flexuous and interlacing. The medullary filaments in all species of *Amphiroa* are straight and parallel, with cells in long and short zones alternating in various ways. In the other genera the medullary filaments are likewise straight, but the cells are in zones of uniform length.

Yendo(36) definitely illustrates marked variations in the medullary structure of various species of the articulated corallines, but he seems to belittle the value of such structures in the segregation of the different genera. Weber van-Bosse,(32) on the other hand, emphasizes the fundamental value of such structures in her attempt to segregate the different genera. She points out that the intergenicular medulla of *Amphiroa* is made up of straight filaments with rows of short cells and rows of long cells alternating in various ways, depending upon the species, while in *Corallina*, *Jania*, *Arthrocardia*, *Cheilosporum*, and *Metagoniolithon* the medullary filaments are likewise straight, but the cells are in rows of equal length; in *Lithothrix* the medulla is merely a single zone of long cells. Yendo(38) later finds marked structural variations in the intergenicular medulla, but considers such structural variations as of little generic value, using them only in making distinctions between his different sections of the

genus *Amphiroa*. In a study of the structure of a very large number of species of the articulated corallines, collected from the Pacific coast of North America and obtained from herbarium materials from other parts of the world, made available through the courtesy of the different European herbaria, there have been found not only profound structural variations of the intergenicula, of the medulla in particular, but also their value in a more logical generic segregation within the group of the articulated corallines than visualized even by Dr. Weber van-Bosse. Summarizing, species of *Amphiroa* are made up of straight and parallel filaments and zones of long and short cells variously alternating; in *Corallina, Bossea, Cheilosporum, Pachyarthron, Arthrocardia, Duthiea, Joculator,* and *Metagoniolithon* the medullary filaments are likewise straight and parallel, but the cells form zones of uniform length; in *Calliarthron* the filaments are flexuous and interlacing; and in *Lithothrix* the medulla is merely a single horizontal row of long cells.

THE BRANCHES

In the earlier part of this account it was pointed out that the erect segmented fronds arising from the crusts, as growth proceeds, soon cease to be simple, but branch, the branches likewise becoming segmented and arranged in various fashions in the different genera and in the different species. To these branches various designations have been given, *rameux*,(5, p. 63; 17, pp. 266–292; 30) branches,(10, 27, 32) *rami*,(2, 3) *zweige*,(13) and *aeste*, 25, p. 269) but in this account the designation branches (English equivalent of the other terms) will be used consistently.

The branches are made up of genicula and intergenicula, or structures structurally comparable to the genicula and intergenicula and showing structural expressions of the main erect fronds. The number of genicula and intergenicula that constitute a branch varies in different genera and in different species. In *Corallina* and *Bossea,* for example, a branch may be made up of a single geniculum and an upper segment, intergenicular in structure, which, in certain species of *Corallina,* serves as the sole bearer of the reproductive organ, the conceptacle. In the majority of cases it may itself repeatedly branch, producing a pinnate or even bipinnate or pinnately decompound structure in certain species of *Corallina, Bossea, Calliarthron* and *Joculator;* verticillate or dichotomous-verticillate in *Metagoniolithon;* dichotomous in *Amphiroa;* dichotomous or dichotomous-cymoid in *Jania;* irregular in *Pachyarthron* and in *Lithothrix;* and pin-

nate-cymoid in *Arthrocardia* and *Duthiea*. In general, in species of *Corallina, Bossea, Calliarthron*, and *Joculator*, the fronds are distichous, with branches either opposite, alternate, or subalternate, depending on the species. In *Corallina* (*Eucorallina*) *armata* Hook. f. et Harvey, (10, p. 103, pl. 40, figs. 1–7) however, the fronds are partly distichous and partly polystichous, on account of simple ramules arising on the flat surfaces on the upper ends of certain intergenicula. In *Corallina* (*Cornicularia*) *Cuvieri* Lamouroux (17, p. 286, pl. fig. 8, *a*, *b*) the primary branches are distichous and opposite, while the branchlets are dichotomous. In certain species of *Metagoniolithon* [*Metagoniolithon charoides* (Lamx.) Weber van-Bosse] (32, p. 102) the branching is entirely verticillate (polystichous), while in other species [*Metagoniolithon gracile* (Harvey) Yendo] (38, p. 12) the branching on the lower parts is verticillate (polystichous), on the upper parts strictly dichotomous. In *Lithothrix* primary branching is dichotomous and secondary branching spiral.

According to available literature, the mode of development of branches in the articulated corallines has not been traced to any considerable extent. Yendo (38, p. 27) merely states (citing *Amphiroa fragilissima* and *A. valonoides* as examples) that

> The primary stage of the ramules is a mamillary process on the surface of the articulus. It is built up with a number of layers of globular or rectangular cells not distinguishable from the cortical cells. As the process elongates upwards by intercalary growth of the cells of one or more layers, the geniculum is transformed from one of the elongated cell layers.

Oltmanns (25, pp. 269–271) gives only an account of the early stages of development in *Corallina*, when certain cells of the medullary filaments elongate and, after attaining a certain length, short segments are marked off at the distal ends, the lower segments becoming the geniculum and the upper segments, the flabellate meristem. In this study of the development of the branches it has been found that the branches arise always on the upper portions of the intergenicula, except in the following three sets of cases: in *Metagoniolithon* they arise from any portion of the cortex of the genicula; in certain species of *Amphiroa* and in the case of the secondary branches of *Lithothrix*, they arise from any portion of the side (cortex) of the intergenicula. Normally, and where they arise from the upper portion of the intergenicula, the branches are medullary in origin, while in the special three cases just mentioned they are cortical in origin. In a large number of species, particularly those with regular dichotomous branching, the branches are developed from the apical

meristem. Prior to the development of the branches, the growing apex has a conical or semicircular shape. In the early stage of the development of the branches certain regions of the apical meristem become less active than the other regions, resulting in the formation of lobes, two in dichotomous, three in pinnate, four or more in extreme cases. In certain instances these lobes elongate considerably prior to the development of the genicula, so that the branches appear as if borne on stalks. In the development of a branch or upper segments in species with unizonal genicula, certain cells of the apical meristem elongate considerably, and short segments are marked off at the distal ends, the lower segments becoming the geniculum and the apical segments the flabellate meristem. The cells of the central region of the apical meristem elongate vertically and divide merely by transverse division, producing the rows of cells of the medulla, while the cells of the lateral regions elongate obliquely and divide both longitudinally and transversely, producing the cortical tissue. The development of the branches in species with multizonal genicula is essentially the same as that of the species with unizonal genicula, except that in the former case the apical meristem undergoes several transverse divisions in the production of the genicula.

In what may be considered the usual or normal cases, the branches arise directly from the growing apices as first described, but in *Metagoniolithon* they arise from the subepidermal layer of the genicular cortex; in *Lithothrix* the secondary branches arise from the extreme inner layer of the intergenicular cortex, and in certain species of *Amphiroa* they arise from the subepidermal layer of the intergenicular cortex. In these three special cases the branches arise from seemingly matured tissue. In the early stage of development in these three special cases, certain seemingly matured cells of the tissue concerned become meristematic, producing branch primordia which undergo development in a fashion similar to that described as the normal procedure.

A number of authors (cited below in connection with taxonomy) have made clear the value of the differences in the modes of branching in attempting a logical classification of the articulated corallines. A study of the modes of branching of a large number of species of the different genera brought out indications of their importance in the segregation of the different genera, and likewise in the segregation of the different species.

In *Corallina* (*Corallina officinalis*) and in certain species of *Bossea* (*Bossea plumosa*) the branching is pinnate; in *Jania* (*Jania rubens*), *Cheilosporum* (*Cheilosporum sagittatum*), and in most species of *Amphiroa* (*Amphiroa fragilissima*), the branching is definitely dichotomous; in *Metagoniolithon* (*Metagoniolithon charoides*) the branching is verticillate; in *Lithothrix* (*Lithothrix aspergillum*) the main branches are dichotomous, but the branchlets are not uniform in their arrangement; in *Corallina Cuvieri* and in *C. corniculata* (14, pls. 69, 70) the primary branches are truly dichotomous, while the branchlets are arranged pinnately; in *Arthrocardia* and *Duthiea* the branching of the sterile fronds is pinnate but cymoid when fruiting; in *Pachyarthron* the branching is composite, dichotomous, or irregular-dichotomous.

LIFE HISTORY

The life history of the articulated corallines has never been traced chronologically and completely for any one of the known species, but indications seem to prove beyond doubt that it is essentially similar to that of *Corallina officinalis* var. *mediterranea*, studied by Yamanouchi.(34) According to this author, the life cycle of this species involves three types of plants, the tetrasporic, cystocarpic, and antheridial, all similar to one another. Unfortunately, however, Yamanouchi was unable to follow through the life cycle. His culture plants reached only the early crustaceous stages. From the tetraspores he was able to study only 13-celled crustaceous plants, and 17-celled crustaceous plants from the carpospores. From the relative number of chromosomes, however, his inferences are that the carpospores germinate into tetrasporic plants and the tetraspores into sexual plants (cystocarpic and antheridial). The carpospores have forty-eight chromosomes (2n) and the tetraspores, twenty-four chromosomes (n), reduction taking place in the first division in the formation of tetrads. Unfortunately it has not been possible in this study to carry through any cultures, and judgment along the lines of relations between the different stages of development is possible only through their comparison, framed through extensive collections of plants growing in nature. From general observations on species represented on the coast of California, particularly on various species of *Corallina* and *Calliarthron*, there is no apparent difference in the microscopic structure of the fronds (genicula and intergenicula) between the sexual and asexual plants. In size, under practically the

same conditions, however, the sexual plants appear very much smaller than the asexual plants. In the genera not represented on the coast of California only the tetrasporic plants have been available. The inference seems borne out by general experience that the sexual plants of all genera are probably very much smaller than the asexual plants.

In 1878 Thuret (30, p. 93) observed that the three types of reproductive organs in *Corallina officinalis* var. *mediterranea* are borne on three different sets of individuals. In *Jania rubens*, however, the cystocarpic and the antheridial conceptacles are found in the same plants, and the tetrasporic conceptacles on different individuals. (30, pp. 99, 100) In the species collected on the coast of California no cases of monœcism were detected. Differences in shape of the different kinds of conceptacles (tetrasporic, cystocarpic, and antheridial) were observed in *Jania rubens* and in *Corallina officinalis* var. *mediterranea* by Yamanouchi. (34) In our specimens collected from the coast of California these differences in shape of the different kinds of conceptacles are likewise detected. In species of *Corallina* the antheridial conceptacles are more elongated than the tetrasporic conceptacles, and the apices are attenuated. Of this species, tetrasporic and antheridial plants only were collected, so that nothing can be said about the shape of the cystocarpic conceptacles. In species of *Calliarthron*, such as *Calliarthron cheilosporioides* and two others published in another paper, the tetrasporic conceptacles are semiglobular, the cystocarpic conceptacles conical with blunt apices, and the antheridial conceptacles likewise conical but with attenuated apices. From these indications it is highly possible that in the species of the other genera only the tetrasporic stages of which are known at present, the different kinds of conceptacles (if they produce likewise those different kinds of conceptacles) have likewise different shapes.

THE CONCEPTACLES

The reproductive organs of the articulated corallines are borne in a receptacle called *conceptaculum*, (6, 32) *ceramidium*, (10; 11, pl. 222) *keramidium*, (3) conceptacle, (30, pp. 94–96) and *Konceptakulum*; (13; 25, p. 365) in this account the designation conceptacle (plural, conceptacles) will be used uniformly.

The development of the conceptacles of the articulated corallines, judging by available records, has not been traced to any

considerable extent. All published accounts along these lines have dealt merely with a single species (*Corallina officinalis*). According to Thuret,(30) the early stages of the development of a conceptacle of *Corallina officinalis* consist of the inhibition of the growth of the central region of the apical meristem of a branch, accompanied by decalcification and the gelatinization of the cell walls of the central tissue, followed by the sloughing off of their cuticular covering. While these activities are going on, the filaments of the peripheral regions remain meristematic, growing up and producing the enclosing conceptacle wall. From the tissue at the base of the cavity of the conceptacle thus formed the reproductive organs arise, whether tetrasporangia, carpogonia, or antheridia. In the formation of the tetrasporangia the basal cells of the conceptacle produce vertical club-shaped protrusions which undergo transverse divisions forming the tetraspores. The antheridia in *Jania rubens* (L.) Lamouroux,(28, p. 543, fig. 288) in *Corallina mediterranea* Areschoug, (25, p. 365, fig. 3) and in *Calliarthron cheilosporioides* Manza(22, p. 46) arise not only from the bases of the conceptacles but also from the inner sides of the conceptacular cavities. These indications lead to the inference that the development and origin of the antheridia in all species of the articulated corallines are similar. The early stages of the development of the antheridia are closely similar to those of the tetrasporangia, except that the vertical protrusions are very much slenderer. In the development of the sperms the protoplasm collects at the distal ends of the protrusions, accompanied by slight swelling of those apices. Ultimately the walls dissolve, setting free globular structures (sperms) each provided with a polar flagellumlike structure consisting of the cytoplasm that has not been used up in the formation of the sperm proper. Thuret does not seem to have followed the stages of the development of the cystocarps to any considerable extent. He merely states that the basal filaments of the conceptacles give rise to the trichophoric apparatus of cylindrical cells. All these cells divide transversely, the basal segments remaining short, forming carpogonia, while the terminal segments elongate, forming the trichogynes. The carpospores arise from the carpogonia situated at the periphery of the trichophoric system. The formation of carpospores consists of the elongation and swelling of the carpogonial cells accompanied by transverse division, the apical segments undergoing

further successive divisions (two or three), forming segments which becomes spherical, which later are set free as carpospores. Yamanouchi(34) merely states:

> Generally the conceptacles are formed at the ends of the branches of the thallus. The reproductive organs, which arise within the conceptacles originate from the so-called disk cells which compose the central portion of the growing apex of each branch. The disk cells located at the periphery continue to divide and grow around the reproductive organs leaving only small aperture or ostiole at the apex, thus forming the conceptacle. The 3 kinds of reproductive organs (tetraspores, antheridia, and carpogonia) are produced in conceptacles on 3 different individuals.

In the formation of the tetraspores the disc cells divide into two, the lower segments forming the stalk cells, the upper, the tetraspore mother cells. The tetraspore mother cells elongate and become club-shaped, accompanied by two successive nuclear divisions, the first being heterotypic, the second, homotypic, and followed by transverse wall formation, resulting in the formation of the tetraspores. The disc cells, in the formation of the male reproductive organs, likewise divide into two, the basal segments forming the stalk cells, the upper, the antheridia. The antheridia elongate and the nuclei divide once. One of the daughter nuclei in each antheridium migrates to the apex and the other migrates towards the base, followed by transverse wall formation between the two nuclei. The apical cells enlarge and become spherical; these are set free as spermatia. In the formation of the female reproductive organs the disc cell undergoes transverse division, the lower segment forming the stalk cell, the upper segment, the auxiliary cell. The auxiliary cell, in turn, gives rise to two lateral cells, only the older one of which becomes functional. This older cell elongates and the nucleus divides into two nuclei one of which remains in the swollen base to constitute the carpogonial or egg nucleus, while the other moves to the tapering upper portion of the cell, the trichogyne, and functions as a trichogyne nucleus. The early stages of the development of the cystocarp consist in the fusion of the spermatium and the egg, accompanied by the fusion of the auxiliary cells (numbering 60 to 70 in each conceptacle) resulting in the formation of a large central cell. The fertilized nuclei then migrate to the central cell and arrange themselves along the periphery. Each of the sporophyte nuclei divides once, forming two daughter nuclei, one of which remains in the central cell while the other migrates to the lateral process produced by the

central cell. The cells on the surface of the central cell undergo repeated transverse division, forming chains of cells which enlarge and become spherical. These cells are finally set free as carpospores.

In my own study of the early stages of the development of the conceptacles of a large number of species of the different genera, I found two types of development: the *Corallina* type of conceptacular development, and the *Amphiroa* type of conceptacular development. To the *Corallina* type belong the conceptacles of species of *Corallina, Jania, Joculator, Duthiea, Arthrocardia, Cheilosporum, Calliarthron,* and *Bossea,* while to the second group belong those of the species of *Lithothrix, Amphiroa,* and *Metagoniolithon.* In *Calliarthron* and *Bossea* the conceptacles are not developed on the actively meristematic regions of the branches, but rather on the seemingly matured intergenicula. In the beginning of the development of the conceptacles in these two genera certain cells of the outermost layer of the intergenicular cortex become actively meristematic, dividing transversely and thereby producing a peripheral layer of cells which soon becomes thick-walled. This layer serves as a protective covering of the conceptacular primordium. After this initial stage the subsequent stages are closely similar to those found in the other genera of this group of the *Corallina* type, which in turn are closely similar to that described by Thuret(30) for *Corallina officinalis,* except that prior to the development of the reproductive organs, whether tetrasporangia, carpogonia, or antheridia, the basal tissue of the conceptacular cavity undergoes development forming parenchymatous tissue from which arise the reproductive organs.

As in the cases of *Calliarthron* and *Bossea,* the conceptacles of *Amphiroa, Lithothrix,* and *Metagoniolithon* arise from the seemingly matured cortex of the intergenicula. In the early stages of the development of the conceptacles in the latter three genera a layer of cells of the intergenicular cortex, situated one or more layers below the epidermis, becomes meristematic, while the surrounding layer or layers of cells remain inactive. The cells of this meristematic layer elongate radially, the cells of the central region elongating more rapidly than the cells of the peripheral regions, thus producing emergences on the surfaces of the intergenicula. The elongation of the meristematic cells forces the nonmeristematic layer or layers of cells to rupture, the apical regions of the emergences thus creating an opening. The cells

at the region of breakage become meristematic, undergoing mostly radial division, thus producing the ostiolar portion of the conceptacle. In these three genera it appears that the basal tissue of the conceptacle becomes directly the propagating tissue.

The stages of the development of the reproductive organs in various plants studied by me have not been traced consecutively, but indications show that they are the same throughout the whole group and follow the stages described by Thuret and Yamanouchi for *Corallina officinalis*. As has been stated in conjunction with the life history of this group, the three kinds of conceptacles (tetrasporic, cystocarpic, and antheridial) have thus far been found only in certain species of *Corallina, Calliarthron,* and *Jania,* while the accessible materials of the other genera (*Amphiroa, Lithothrix, Metagoniolithon, Pachyarthron, Arthrocardia, Cheilosporum, Duthiea, Joculator,* and *Bossea*) have thus far provided only tetrasporic conceptacles. The reproductive organs, except the antheridia, arise from the bases of the conceptacular cavity, except in *Duthiea Setchellii* and certain species of *Arthrocardia* (which are described in another paper), where the tetraspores have been found to arise both from the base and the wall of the conceptacle. As has been reported, the tetraspores are in transverse zones within the tetrasporangium. The antheridia are slender, club-shaped filaments, each giving rise to one spermatium with a polar flagellumlike structure, resembling that reported by Thuret in *Corallina officinalis*. The appendage, according to Thuret, is not a motile organ, but rather a part of the cytoplasm which has not been completely consumed in the formation of the spermatium proper.

Several authors (cited below in conjunction with the taxonomy of this group) have emphasized the fundamental value of the varying positions of the conceptacles in distinguishing the different genera of the articulated corallines. This indication has been confirmed in my own study of a large number of species of the group. In *Corallina, Jania, Arthrocardia,* and *Duthiea* the conceptacles are practically all terminal or apical; in *Joculator,* both terminal and lateral; in *Cheilosporum,* on the upper margins of the wings of the intergenicula; and in *Calliarthron, Amphiroa, Pachyarthron, Bossea, Lithothrix,* and *Metagoniolithon,* they are scattered over the surfaces of the intergenicula.

In connection with the position of the conceptacles, we have applied the terms terminal and lateral.(22, pp. 45, 47) Terminal conceptacles are found, as indicated, in all species of *Corallina,*

Jania, Arthrocardia, Duthiea, Joculator, and in certain species of *Calliarthron,* while lateral conceptacles are found in all species of *Amphiroa, Bossea, Lithothrix, Cheilosporum, Calliarthron, Pachyarthron,* and *Joculator.* Schmitz and Hauptfleisch,(28, p. 540) however, seem to have a different viewpoint in regard to the interpretation of the conceptacles being terminal, when they emphatically designate the conceptacle of both *Corallina* and *Cheilosporum* as terminal. In *Corallina,* for example, the conceptacles are borne on the apices of the segments. They arise from the apical meristem, and in their development the entire apical meristem is used up, terminating the axial growth of the segments. Conceptacles developed in this fashion are practically upright, except in *Duthiea* where they are slightly tilted sideways. To these conceptacles the term "terminal conceptacles" is applied. In the case of *Amphiroa,* on the other hand, the conceptacles are borne on the seemingly matured portions of the segments. They arise from the cortex, and appear as lateral projections on the segments. To the conceptacles borne in this fashion the term "lateral conceptacles" is applied.

In dealing with the positions of the conceptacles (*a*) their origin and (*b*) their position relative to the axes of the segments from which they arise are to be considered. Terminal conceptacles are those on the apices of the segments and springing from the apical meristem; and the lateral conceptacles are those on the sides of the segments and springing from the seemingly matured tissue. In a sense, likewise, terminal conceptacles are primary in origin while the lateral conceptacles are secondary in origin, since the former spring from the apical meristem and the latter from the seemingly matured tissue (by secondary meristem).

HISTORICAL SKETCH OF THE GENERIC CONCEPTIONS

According to available records, a number of the articulated corallines were known and studied as early as the middle of the 18th century, but no attempt was made to segregate them among the different genera. All species known about that time were referred merely to a single genus, *Corallina,*(7, 8, 21) a genus likewise including other calcified algæ such as species of *Halimeda* (green algæ) and *Galaxaura* (red algæ). In the early part of the 19th century, however, great interest arose in the taxonomy of the algæ, and from this time on to the early part of the 20th century a number of works dealing with the genera

of the articulated corallines were published. Lamouroux, in 1812(16) and 1816,(17) established three genera of the articulated corallines distinguished primarily by the modes of branching: *Amphiroa,* with branching dichotomous or verticillate and the "articuli" separated by cushions of an opaque and horny substance; *Corallina,* with branching trichotomous; and *Jania,* with branching dichotomous. Decaisne in 1842(6, pp. 119–125) adopted the three genera established by Lamouroux, but further distinguished *Cheilosporum* and *Arthrocardia* as subgenera of the genus *Amphiroa.* In his account he placed particular emphasis on the position of the conceptacles in distinguishing the three genera: *Corallina,* with terminal conceptacles and with irregular branching; *Jania,* with conceptacles provided with two or four horns of ramuli and with branching either pinnate or dichotomous; and *Amphiroa,* with conceptacles scattered over the surfaces of the articuli. Areschoug(3) recognized 5 genera by elevating *Cheilosporum* and *Arthrocardia* (the two subgenera of Decaisne) to generic rank in addition to three genera already established, recognizable thus: *Amphiroa,* with terete-filiform, subterete, compressed or flat fronds; with branching di- or trichotomous or "dichotomo-verticillata;" with the cortical cells of the articuli small, and of the interior, long and in uniform transverse zones; with polymorphic articuli, genicula corticated, and conceptacles scattered over the articuli; *Cheilosporum,* with the base of the frond terete and flat towards the upper parts, the cortical cells of the articuli elliptic-roundish, and of the interior, long and in uniform transverse zones, articuli sagittate or obcordate, genicula noncorticated, and the conceptacles on the upper margins of the lobes of the articuli; *Arthrocardia,* with fronds subterete near the base and compressed to flat towards the top, the cells of the cortex of the articuli elliptic roundish and of the interior long and in uniform transverse zones, pinnate-branching, the conceptacles terminal on the apices of the articuli, and with noncorticated genicula; *Jania,* with dichotomous branching, the cells of the cortex of the articuli oblong and of the interior filiform and subcontinuous, articuli cylindrical, subclavate or subhastate, genicula noncorticated, and conceptacles terminal and provided with horns; *Corallina,* with branching pinnate, the cells of the cortex of the articuli subspherical and of the interior filiform and elliptical and in uniform transverse zones, articuli compressed or complanate, genicula noncorticated, and terminal conceptacles with or without horns. Areschoug, in addition to elevating *Arthrocardia* and *Cheilosporum* to

generic rank, restored to independent generic rank the genus *Jania* of Lamouroux and referred back all the pinnate species of *Jania* Decaisne to species of *Corallina*. In 1867 J. E. Gray(9) proposed an additional monotypic genus, *Lithothrix* (*L. aspergillum*), recognizable by pustuliform conceptacles scattered on the articuli, pinnate- or verticillate-branching, and articuli short, compressed on the upper parts of the main branches and cylindrical on the branchlets. In 1897 Schmitz and Hauptfleisch(28, pp. 542, 543) adopted only 3 genera, *Amphiroa*, *Cheilosporum*, and *Corallina*, reducing *Arthrocardia* to a synonym under *Cheilosporum* and *Jania* to a synonym under *Corallina*. These authors segregated the three genera by the positions of the conceptacles: in *Amphiroa* conceptacles scattered over the flat surfaces of the joints; in *Cheilosporum* conceptacles terminal, immersed in the apices of the hornlike projections of the joints; in *Corallina* conceptacles likewise terminal, but immersed in the apices of the branches. Incidentally, Schmitz and Hauptfleisch were the first to call attention to the fact that the conceptacles in *Arthrocardia* are strictly terminal, a viewpoint that will be considered in detail later when we deal with the genus *Arthrocardia* and with the genus *Cheilosporum* the conceptacles of which they interpreted as terminal. In 1904 Weber van-Bosse(32) recognized eight genera, distinguishable primarily not only by the position of the conceptacles but also by the structure of the genicula and of the intergenicula. The generic distinctions of this author are summarized in her "Synoptical Key" which runs as follows:–

I. Fronds branched, articulated, calcified joints separated by horny pliable nodes. Joints consisting of a more or less developed cortical layer. Conceptacula either occurring as wart-like or conical processes on the joint or immersed in the tissue of the joint.

a. Joints cylindrical or broadened; in the central strand, rows of short cells are intercalated between rows of the cells all standing vertically one above the other. Nodes consist of 2 or more, rarely one, rows of cells that alternate in the same way as, and have the same size or almost the same size as, the cells of the joint. Conceptacula on the joint.

Amphiroa Lamx.

b. Joints cylindrical; in the central strand the cells have throughout the whole joint almost the same dimension and stand vertically one above the other. Nodes consist of many rows of cells which are much smaller and have thicker walls than the cells of the joint. Conceptacula on the joint....*Metagoniolithon* g. n.

c. Joints flat short elliptical in outline, with a central strand of non-calcified, intricated filaments, with cells not standing vertically one above the other, and with a considerable layer of calcified cortical cells. Cells of the cortical layer large, near central strand full of big grains of starch, growing smaller towards the periphery, covered by a thick cuticle. Nodes consist of small thick-walled cells. Conceptacula unknown. *Litharthron* g. n.

d. In the central strand all the cells have almost the same dimension throughout the whole joint. Nodes consist of one row of long cells.

1. Joints cylindrical or broadened wing-like; conceptacles form conical protuberances on the joint..... *Arthrocardia* Aresch.
2. Joints cylindrical or broadened wing-like; conceptacles on the upper margin of the broadened wing, immersed in the tissue of the joint ..... *Cheilosporum* Aresch.
3. Joints cylindrical or flattened; conceptacles at the growing top of the branches, immersed in the tissue of the joint. *Corallina* Lamx. incl. *Jania* Lamx.

II. Fronds branched, articulated, cylindrical, calcified joints separated by calcified constrictions of the frond. The joints consist of central strand of long, undivided non-calcified filaments standing in vertical rows with the calcified cells of the constrictions, and of a cortical layer of calcified horizontally elongated cells. Conceptacula on the joints..... *Lithothrix* Gray.

Yendo(38) in 1905 recognized only 7 genera by reducing *Arthrocardia* to a section of the genus *Amphiroa*. According to this author, *Amphiroa* has the propagating cells generated in the cortex, the conceptacles on the margins or on the flat surfaces of the articuli, the genicula unizonal or multizonal, and the intergenicular medulla with several zones of "articoli" interposed with zones of "otricoli" or with zones of "articoli" only; *Metagoniolithon* has the propagating cells generated in the medulla, genicula multizonal, and cylindrical articuli and verticillate ramuli; *Lithothrix* has the propagating cells generated in the medulla, the genicula not especially differentiated, the main branching dichotomous, with compressed articuli, and ramuli pinnate, with cylindrical articuli; *Cheilosporum* has the propagating cells generated in the medulla, genicula unizonal, and conceptacles sessile and immersed in the articuli or pinnulets; *Corallina* has the propagating cells generated in the medulla, unizonal genicula, stalked conceptacles, and pinnate branching; *Jania* has the propagating cells generated in the medulla, unizonal genicula, stalked conceptacles, and dichotomous branching; and *Litharthron* has

the propagating cells generated in the medulla, the genicula multizonal, flat articuli, and branching di- or trichotomous.

In the final analysis it has been found that (*a*) in foregoing attempts to distinguish the different genera of the articulated corallines there is no definite uniformity in the characters used, which makes their application most uncertain; (*b*) in all these attempts no consistent effort has been made to determine the type species on which the different genera are founded and to associate with the generic names only species closely related to these types. In the following, an effort will be made to determine the proper type species of each genus and to more clearly determine proper generic limits and specific relationships in accordance with consistency as to type species.

Of the 8 genera thus far proposed (*Amphiroa, Arthrocardia, Cheilosporum, Corallina, Jania, Litharthron, Lithothrix,* and *Metagoniolithon*), the genus *Litharthron* cannot, in the sense of our interpretation, be related to the other articulated corallines. Specimens of *Litharthron australis* from Anna Weber van-Bosse as well as the Harvey specimens (Herbarium of the British Museum and Kew Herbarium) referred to *Amphiroa australis* Sond., on being carefully studied, fully confirmed this point of view. In addition, in 1931, Yamada,(33) after a thorough study of the type, convinced himself that the chosen type of *Litharthron, Amphiroa australis* Sond., is a species of *Rhodopeltis.* The genus *Litharthron* will therefore not be included in the following consideration. During the study of a large number of species of the articulated corallines collected from the west coast of North America and from various parts of the globe, made available through the courtesy of the different European herbaria, there have been found a number of species that cannot be referred to any proposed genera, so that it will be necessary not only to revise the genera already established but also to describe four new genera as well as two new distinguished subgenera to which these species may be referred.

Key to the genera of the articulated corallines.

Plants with terminal conceptacles ..... 1.
Plants without terminal conceptacles ..... 7.
1. Conceptacles all terminal ..... 3.
1. Conceptacles both terminal and lateral ..... 2.
2. Intergenicular medullary filaments straight ..... 1. *Joculator* Manza.
2. Intergenicular medullary filaments flexuous and interlacing. 2. *Calliarthron* Manza.

3. Branching dichotomous or dichotomous-cymoid..... 3. *Jania* Lamx.
3. Branching wholly or partially pinnate, or pinnate-cymoid..... 4.
4. Branching wholly or partially pinnate. 4. *Corallina* L. (emend. Lamx.) ..... 5.
4. Branching pinnate-cymoid (pinnate on vegetative parts and cymoid on fruiting parts) ..... 6.
5. Conceptacles nonantenniferous.
4*a*. *Corallina* (*Eucorallina*) subgen. nov.
5. Conceptacles antenniferous.
4*b*. *Corallina* (*Cornicularia*) Manza.
6. Conceptacles upright (pores apical).
5. *Arthrocardia* Decne. (emend. Aresch.).
6. Conceptacles oblique (pores slightly lateral).
6. *Duthiea* Manza.
7. Conceptacles restricted on upper margins of upper lobes of intergenicula..... 7. *Cheilosporum* Aresch.
7. Conceptacles scattered over surfaces of intergenicula.... 8.
8. Genicula unizonal..... 9.
8. Genicula multizonal..... 13.
9. Intergenicular medulla unizonal.... 8. *Lithothrix* Gray.
9. Intergenicular medulla multizonal..... 10.
10. Intergenicular medullary filaments straight..... 11.
10. Intergenicular medullary filaments flexuous and interlacing ..... 2. *Calliarthron* Manza.
11. Intergenicular medullary cells in transverse zones of equal length..... 12.
11. Intergenicular medullary cells in transverse zones of long and short cells.
9. *Amphiroa* Lamx. (emend. Weber van-Bosse).
12. Intergenicula compressed.... 10. *Bossea* Manza.
12. Intergenicula cylindrical.
11. *Pachyarthron* Manza.
13. Intergenicular medullary cells in transverse zones of equal length.
12. *Metagoniolithon* Weber van-Bosse.
13. Intergenicular medullary cells in transverse zones of long and short cells.
9. *Amphiroa* Lamx. (emend. Weber van-Bosse).

1. Genus JOCULATOR Manza

Joculator MANZA, Proc. Nat. Acad. Sci. U. S. A. 23 (1937) 47.

Fronds fragile; branching pinnate, mostly pinnate-decompound; segments near base cylindrical or compressed, on upper parts compressed; genicula unizonal; intergenicular medullary filaments straight, with cells in transverse zones of equal length; conceptacles terminal in apices of ramules, lateral on flat surfaces of intergenicula.

Type species: *Joculator pinnatifolius* Manza.

Specimens of the species of this genus have been collected thus far only from the coast of Central California by F. M. Reed, and from Japanese shores (Boshu, Kazusa, Misaki, and Shimoda Provinces) by Yendo. (36, p. 22; 38, p. 26) Species of this genus bear characters of *Corallina* and *Bossea*, having terminal conceptacles borne in the same fashion as those of *Corallina*, and lateral conceptacles borne in similar fashion as those of *Bossea*. In addition, the microscopic structure of the genicula and of the intergenicula of these genera, *Bossea*, *Corallina*, and *Joculator*, are similar: unizonal genicula; intergenicular medullary filaments straight with cells in transverse zones of equal length. Species of these three genera merely differ in the positions of the conceptacles: in *Corallina* the conceptacles are terminal and restricted on the apices of the ramules; in *Bossea* they are limited to the flat surfaces of the intergenicula; and in *Joculator* they are terminal on the apices of the ramules and likewise lateral on the flat surfaces of the intergenicula. *Joculator pinnatifolius* is a very slender species. It has cylindrical or slightly compressed segments near the base and has comparatively thick, flattened, cuneate segments on the branches. The primary divisions of the fronds (or branches) consist of simple ramules below, and long branches above, and these are in turn once or twice pinnately divided, with the divisions likewise made up of simple ramules below and long branchlets above. The ultimate divisions of the branches in this species are always made up of simple ramules. In this species practically all segments except those nearest the base bear opposite members, either simple, short ramules or long, compound branches. The terminal conceptacles are borne on the apices of simple ramules like those of *Corallina officinalis* L., and the lateral conceptacles are borne on the flat surfaces of the ramules, like those of *Bossea plumosa*.

Key to the species of Joculator.

a^1. Fronds 4 to 7 cm long..... 1. *J. pinnatifolius* Manza.
a^2. Fronds 12 cm long..... 2. *J. maximus* (Yendo) Manza.

JOCULATOR PINNATIFOLIUS Manza. Plate 1, figs. 1 and 2.

Joculator pinnatifolius MANZA, Proc. Nat. Acad. Sci. U. S. A. 23 (1937) 47.

Fronds erect, 4 to 7 cm long; branching plumosely bi- or tripinnate and opposite; primary branches consisting of ramules and

long branches once or twice divided, ultimate branches always composed of ramules; intergenicula near base cylindrical or slightly compressed, 1 mm long and 1 mm in diameter, on upper parts on primary branches compressed-cuneate, 1 mm long and 1 to 2 mm broad, on ramules awl-shaped or spathulate, 1 to 3 mm long and 1 mm broad; conceptacles terminal on apices of unsegmented ramules, antenniferous or nonantenniferous, and 2 each on flat surfaces of intergenicula, borne singly near upper lobes. Cystocarpic and antheridial plants unknown.

Type specimen.—Tetrasporic, *Herb. Univ. Calif. No. 545769.* Orange county, coast of Central California; west coast of North America.

Only a single additional species has been described thus far that may be properly referred to this genus.

JOCULATOR MAXIMUS (Yendo) Manza.

Joculator maximus (Yendo) MANZA, Proc. Nat. Acad. Sci. U. S. A. (11) 23 (1937) 567.

Cheilosporum maximum YENDO, Journ. Coll. Sci. Imp. Univ. Tokyo 16 (1902) 22, pl. 2, figs. 18, 19; pl. 6, fig. 9; 20 (1905) 26.

Fronds 12 cm long; branching plumosely bi- or tripinate and opposite, divisions mostly composed of simple ramules on lower parts and of long branches on upper parts, entirely of simple ramules on branchlets; intergenicula near base cylindrical, 1 to 2 mm long and 1 to 1.5 mm broad, intergenicula of upper parts on branches compressed-cuneate, 1 to 2 mm long and 2 to 3 mm broad, intergenicula of ramules spathulate, 2 to 4 mm long and 1 to 2 mm broad; tetrasporic conceptacles both terminal on apices of ramules with pores apical, and lateral on flat surfaces of intergenicula, 2 on each surface borne singly near upper lobes, with pores central.

Type: *Cheilosporum maximum* Yendo. Type specimen in Herb. Imperial Univ. Tokyo.

2. Genus CALLIARTHRON Manza

Calliarthron MANZA, Proc. Nat. Acad. Sci. U. S. A. 23 (1937) 46.

Fronds extremely fragile; branching dichotomous, pinnate, or dichotomous-pinnate; segments cylindrical or compressed; genicula unizonal; intergenicular medullary filaments flexuous and interlacing; conceptacles semiglobular or conical, borne along margins and flat surfaces of intergenicula, or on apices of ramules, and along margins and flat surfaces of intergenicula.

Type species: *Calliarthron cheilosporioides* Manza.

Species of this genus seem to occur only on the temperate shores. Thus far 10 species are known in this genus; Harvey (specimen in Herb. Kew) collected specimens in Esquimault, British Columbia, and referred them to *Amphiroa rudis*. In 1842 Decaisne (6, p. 112) described *Amphiroa* (*Arthrocardia*) *vertebralis*, collected from Monterey, California. Yendo (36, pp. 16, 19, 21) reported 3 specimens collected from Japan (Kazusa and Hakkodate Provinces) as species of *Cheilosporum*. From the west coast of North America Prof. W. A. Setchell and myself collected 5 new species published in a separate paper.

In the majority of cases species of *Calliarthron* may be distinguished very readily from species of the other genera of the articulated corallines by the position of the conceptacles along the lateral margins of the intergenicula in addition to those on the flat surfaces. Thus far the conceptacles borne along the lateral margins of the compressed intergenicula are found only in most species of this genus. In some species (described in a separate paper), however, the conceptacles are restricted to the flat surfaces of the intergenicula in a fashion similar to those of species of *Bossea*. In this particular case the species of *Calliarthron* differ from species of *Bossea* merely by the structure of the intergenicular medulla. (22, p. 46) In *Calliarthron* the intergenicular medullary filaments are flexuous and interlacing, while in *Bossea* they are straight.

Key to the species of Calliarthron.

a^1. Conceptacles both terminal and lateral.
1. *C. modestum* (Yendo) Manza.
a^2. Conceptacles all lateral.
b^1. Conceptacles restricted on convex surfaces of intergenicula.
2. *C. Schmittii* Manza.
b^2. Conceptacles scattered over surfaces of intergenicula.
c^1. Conceptacles borne on flat surface, along lateral margins, and on upper margins of upper lobes of intergenicula.
3. *C. cheilosporioides* Manza.
c^2. Conceptacles borne on flat surface and lateral margins of intergenicula.
d^1. Branching dichotomous-pinnate..... 4. *C. Setchelliae* Manza.
d^2. Branching pinnate, rarely dichotomous-pinnate.
e^1. Branching pinnate and subalternate.
5. *C. yessoense* (Yendo) Manza.
e^2. Branching pinnate and opposite, rarely subalternate.
f^1. Branching interrupted-pinnate and opposite.
6. *C. regenerans* Manza.

f^2. Branching not interrupted-pinnate.
g^1. Fronds plumosely or densely branched.
7. *C. pinnulatum* Manza.
g^2. Fronds sparsely branched.
8. *C. latissimum* (Yendo) Manza.

CALLIARTHRON CHEILOSPORIOIDES Manza. Plate 2, figs. 1 to 3.

Calliarthron cheilosporioides MANZA, Proc. Nat. Acad. Sci. U. S. A. 23 (1937) 46.

Fronds erect, 10 to 29 cm long; branching loosely pinnate and opposite or subalternate; intergenicula near base cylindrical, 1 to 6 mm long, 1 to 2 mm in diameter, on upper parts compressed-cuneate or obcordate, with rounded lobes 1 to 2 mm long and 2 to 4 mm broad; conceptacles on upper lobes and lateral margins and flat surfaces of intergenicula appearing first along margin 1 to 3, later crowded on flat surfaces, conical with blunt apices in tetrasporic plants, conical with pointed apices in antheridial plants. Cystocarpic plants unknown.

Calliarthron cheilosporioides, the type of the genus, is the largest species known at present, the fronds attaining a height of about 30 cm. It has long-cylindrical, thick, basal segments, and segments on the upper parts uniformly compressed-cuneate or obcordate, with rounded lobes. This species differs from all species of *Calliarthron* in having conceptacles on the upper lobes of the intergenicula in addition to those on the lateral margins and flat surfaces. These conceptacles on the upper lobes of the intergenicula in this species are borne in almost the same fashion as those in species of *Cheilosporum*, so that the designation *Calliarthron cheilosporioides* is chosen to signify the *Cheilosporum*-like nature of the species. Of this species only tetrasporic and antheridial plants have been collected thus far. The antheridial plants are very much smaller than the tetrasporic plants, the former being about 15 cm high and the latter about 30 cm high. The antheridial plants bear conical conceptacles with extremely pointed apices, giving the flat surfaces of the intergenicula a spiny appearance and the lateral margins a serrate outline, while the tetrasporic plants bear conical conceptacles with blunt apices, giving the surfaces of the intergenicula a warty appearance.

Type specimen.—Tetrasporic, *Herb. Univ. Calif. No. 545724;* Pacific Grove, coast of central California; antheridial, *Herb. Univ. Calif. No. 545721.* Pebble Beach, Carmel Bay, coast of central California, west coast of North America. In Herb. Univ. Calif.

There are 9 additional species thus far described which may be properly referred to this genus:

CALLIARTHRON RUDIS (Harvey) Manza comb. nov.

Amphiroa rudis HARVEY (in Herb. Kew).

CALLIARTHRON VERTEBRALIS (Decaisne) Manza comb. nov.

Amphiroa (*Arthrocardia*) *vertebralis* DECAISNE, Mem. sur les Corallines (1842) 112.

In *Calliarthron rudis* and *Calliarthron vertebralis* we have only fragments of probably the type specimens for study, so that specific descriptions are impossible. Study of the fragments shows that the genicula are unizonal, the intergenicular medullary filaments are flexuous and interlacing, and the conceptacles are borne along the margins and flat surfaces of the intergenicula, which are characters of species of *Calliarthron* and not of species of *Amphiroa* under which they were referred previously. As available specimens of those species are merely fragments of the segments, it seems best at present to recognize their present designations and to merely list them under *Calliarthron.*

CALLIARTHRON MODESTUM (Yendo) Manza.

Calliarthron modestum (Yendo) MANZA, Proc. Nat. Acad. Sci. U. S. A. 23 (1937) 564, 565.

Cheilosporum anceps var. *modesta* YENDO, Journ. Coll. Sci. Imp. Univ. Tokyo 16 (1902) 19, pl. 2, fig. 9; pl. 6, fig. 3; ibid. 20 (1905) 20.

Fronds 5 cm long, branching pinnate and opposite to subalternate; intergenicula near base cylindrical or subcompressed, 1 mm long and 1 mm broad, intergenicula of upper parts compressed, mostly obcordate with lobes acute, 2 mm long and 2 to 3 mm broad; tetrasporic conceptacles mostly along lateral margins and flat surfaces of intergenicula, but occurring sometimes on apices of simple ramules.

Type: *Cheilosporum anceps* var. *modesta* Yendo, in Herb. Imp. Univ. Tokyo.

Type locality.—"Hakkodate, Japan."

The type of this species is not available for study, but we have an excellent specimen of the variety whose designation is in the handwriting of Yendo, which shows characters of species of *Calliarthron,* and on which specific diagnosis is based.

CALLIARTHRON YESSOENSE (Yendo) Manza.

Calliarthron yessoense (Yendo) MANZA, Proc. Nat. Acad. Sci. U. S. A. 23 (1937) 566, 567.

Cheilosporum yessoense YENDO, Journ. Coll. Sci. Imp. Univ. Tokyo 16 (1902) 19, pl. 2, figs. 12, 13; pl. 6, fig. 5; ibid. 20 (1905) 20.

Fronds 7 cm long; branching pinnate and subalternate; intergenicula near base cylindrical, 1 to 2 mm long and 1 mm broad, intergenicula of upper parts compressed, obcordate, with lobes rounded, 2 mm long and 2 to 6 mm broad; tetrasporic conceptacles along lateral margins and on flat surfaces of intergenicula.

Type: *Cheilosporum yessoense* Yendo. Topotype specimen: tetrasporic, *Herb. Univ. Calif. No. 90783.*

Type locality.—"Hakkodate, Japan."

The type of this species is not available for examination, but we have excellent material of topotype specimens seemingly collected and determined by Yendo himself, on which the specific diagnosis is based.

CALLIARTHRON LATISSIMUM (Yendo) Manza.

Calliarthron latissimum (Yendo) MANZA, Proc. Nat. Acad. Sci. U. S. A. 23 (1937) 564.

Cheilosporum latissimum YENDO, Journ. Coll. Sci. Imp. Univ. Tokyo 16 (1902) 21, pl. 2, figs. 16, 17; pl. 6, fig. 7; ibid. 20 (1905) 20.

Fronds 7 cm long; branching pinnate and opposite to subalternate; intergenicula near base cylindrical or slightly compressed, 1 to 2 mm long and 2 mm broad, intergenicula on upper parts compressed-obcordate with lobes rounded, 2 to 3 mm long and 3 to 5 mm broad; tetrasporic conceptacles both along margins and on flat surfaces of intergenicula.

Type: *Cheilosporum latissimum* Yendo. Topotype specimen: tetrasporic, *Herb. Univ. Calif. No. 418147.*

Type locality.—Kazusa, Japan.

Since the exact type of this species is not available for study, a topotype seemingly collected and determined by Yendo himself was examined. It bears all essential characters of species of *Calliarthron* according to the present treatment of the genus.

CALLIARTHRON PINNULATUM Manza. Plate 3.

Calliarthron pinnulatum MANZA, Proc. Nat. Acad. Sci. U. S. A. 23 (1937) 565.

Fronds 7 to 11 cm long; branching plumously bi- or tripinnate and opposite (rarely dichotomous-pinnate), primary divisions composed of simple ramules and long branches, once or twice pinnately divided and entirely composed of simple ramules on branchlets; intergenicula near base thick, cylindrical or subcompressed, 1 to 3 mm long and 2 mm broad, on upper parts on branches compressed-cuneate, 2 to 3 mm long and 2 to 3 mm broad, on branchlets spathulate, 2 to 4 mm long and 1 to 2 mm broad; tetrasporic conceptacles on flat surfaces of intergenicula,

mostly 2 on each surface, borne singly near upper margins of upper lobes, single and central on flat surfaces of ramules, with pores central and tetraspores basal.

Type: tetrasporic, *Herb. Univ. Calif. No. 545963;* Moss Beach, San Mateo County, coast of central California, west coast of North America.

CALLIARTHRON REGENERANS Manza. Plate 4, figs. 1 to 4.

Calliarthron regenerans MANZA, Proc. Nat. Acad. Sci. U. S. A. 23 (1937) 565.

Fronds 7 to 15 cm long; branching interrupted-pinnate and opposite or dichotomous-interrupted-pinnate and opposite; intergenicula near base cylindrical or slightly compressed, 1 to 4 mm long and 1 to 2 mm broad, on upper parts on primary branches compressed-obcordate, with rounded lobes, on branchlets cylindrical, 2 to 3 mm long and 1 to 4 mm broad; conceptacles along lateral margins and flat surfaces of intergenicula, 2 to 3 along margins and crowded on flat surfaces, semiglobular in tetrasporic plants, conical with blunt apices in cystocarpic plants, and conical with pointed apices in antheridial plants.

Types: tetrasporic, in *Herb. Univ. Calif. No. 545737;* cystocarpic, *Herb. Univ. Calif. No. 545738;* antheridial, *Herb. Univ. Calif. No. 545775;* Moss Beach, San Mateo County, coast of central California, west coast of North America. Collected by the author.

CALLIARTHRON SCHMITTII Manza. Plate 5.

Calliarthron Schmittii MANZA, Proc. Nat. Acad. Sci. U. S. A. 23 (1937) 566.

Fronds compressed, with midrib prominent and dorsoventral; branching dichotomous or dichotomous-lateral; intergenicula near base cylindrical, 1 to 4 mm long and 1 mm in diameter, on upper parts compressed, convex, with prominent midrib, suborbicular or subobcordate, with margins entire or irregularly lobed, 5 to 10 mm long and 5 to 15 mm broad; tetrasporic conceptacles semiglobular on convex surfaces of intergenicula, borne along midrib; pores central and tetraspores basal.

Type specimen: tetrasporic, *Herb. Univ. Calif. No. 545744;* dredged from 21 to 24 fathoms, Point Loma, coast of southern California, west coast of North America. Collected by W. Schmitt, *D–4303,* U. S. F. C. Str. Albatross, 1904.

We have only fragmentary specimens of the species. According to all indications, the fronds are creeping. This is the

only species of the genus thus far known with convex intergenicula, dorsoventral, and the conceptacles restricted on convex (upper) surfaces.

CALLIARTHRON SETCHELLIAE Manza. Plate 6, figs. 1 to 4.

Calliarthron Setchelliae MANZA, Proc. Nat. Acad. Sci. U. S. A. 23 (1937) 566.

Fronds 9 to 16 cm long; branching dichotomous-pinnate and opposite; intergenicula near base slightly compressed, 1 to 3 mm long and 2 to 3 mm broad, on upper parts compressed-cuneate or obcordate, 2 to 3 mm long and 3 to 5 mm broad, with lobes obtuse; tetrasporic conceptacles semiglobular, cystocarpic conceptacles conical, with blunt apices, antheridial conceptacles conical with pointed apices, borne along margins and flat surfaces of intergenicula, 2 to 4 along margins and crowded on flat surfaces.

Type: tetrasporic, *Herb. Univ. Calif. No. 545733;* cystocarpic, *Herb. Univ. Calif. No. 548906;* antheridial, *Herb. Univ. Calif. No. 548904;* Moss Beach, San Mateo County, coast of central California, west coast of North America. Collected by the author.

3. Genus JANIA Lamouroux

Jania LAMOUROUX, Nouv. Bull. des Sci. par la Soc. Philomat. 3 (1812) 186; Hist. Polyp. Flex. (1816) 266–274.

Fronds fragile; branching strictly or largely dichotomous or dichotomous-cymoid; genicula unizonal; intergenicular medullary filaments straight, cells in transverse zones of equal length; conceptacles terminal in apices of ultimate branchlets or in cymoid clusters with ultimate conceptacles antenniferous or non-antenniferous.

Type species: *Corallina rubens* Linnæus.

There are a considerable number of described species properly referrable to *Jania* with certainty, but as yet without proper designation. According to all indications, species of *Jania*, with the present limits of the genus, are tropical and subtropical.

In 1812 Lamouroux proposed the genus *Jania*, and listed under it 6 species, *Jania spermophorus* Lamx., *J. rubens* (Linn.) Lamx., *J. corniculata* Lamx., *J. fragilissima* (Linn.) Lamx., *J. cristata* Lamx., and *J. granifera* Lamx. In 1816 he included under his revised *Jania*, *Jania rubens*, *J. corniculata*, and 8 other species that seemingly are still referrable to *Jania*. In the same account he reduced *Jania cristata* and *Jania spermophorus* to varieties of *Jania rubens*, referred *Jania fragilissima* to *Amphiroa fragi-*

lissima, and *Jania granifera* to *Corallina granifera*. In 1842 Decaisne (6, pp.110, 111) listed *Jania rubens* and *J. corniculata* among his 4 dichotomous species with terminal and antenniferous conceptacles, and 6 among his pinnate species with terminal and antenniferous conceptacles. In 1852 Areschoug (3, pp. 553–560) described 6 species all of which are species of *Jania* according to the present restrictions of the genus, including *Jania rubens* and *J. corniculata*. In 1897 Schmitz and Hauptfleisch (28, p. 543) included this genus under *Corallina*, and listed *Corallina rubens* Linn. along with *Corallina officinalis* L. and *C. mediterranea* Aresch. as typical species of *Corallina*, having the conceptacles terminal and immersed in the apices of the segments. In 1904 Weber van-Bosse (32, pp. 86, 107, 108) listed 3 species referable to *Jania* as restricted, including *Jania rubens*. In 1905 Yendo (38, pp. 2, 37–41) listed 22 species of *Jania*, including *Jania rubens*, and reducing *J. corniculata* to a variety of *Jania concatenata*. Of these species *Jania rubens* (Linn.) Lamx. is the species first mentioned by Lamouroux and seemingly regarded as typical of *Jania*, so that it seems but proper to designate it as the type of the genus.

In 1816 Lamouroux limited the genus to dichotomous species with slender articuli and practically, as his figures show, but not technically, for he did not say so, to species with terminal conceptacles, his figures (17, pl. 9, figs. 6, 7) of the generic type, *Jania rubens* (Linn.) Lamx., clearly emphasizing the latter viewpoint. Decaisne emphasizes more particularly the presence of the so-called horns in his generic concept, thus including in his genus, *Jania*, antenniferous species not only with dichotomous branching and with terminal conceptacles but also with pinnate branching and terminal conceptacles. Areschoug and Yendo restricted it to species primarily with dichotomous branching. Although she does not draw a definite line of demarcation between *Jania* and *Corallina* in her Synoptical Key to the genera of the Corallineae verae, Weber van-Bosse in her list of species (32, p. 107) recognizes its generic independence. In her Synoptical Key to the genera of Corallineae verae she points out definitely that the genus includes species with unizonal genicula, with the intergenicular medullary filaments straight, with cells in transverse zones of equal length, and seemingly with dichotomous branching, since she includes under *Jania* species only with branching dichotomous, such as *Jania adhaerans* Lamx.,

Jania rubens (L.) Lamx., and *Jania tenella* Kuetz., which can properly be referred to *Jania* as restricted.

From the study of the Linnæan type, of which we have excellent photographs, and species showing all essential characters of the type, as well as other species which are properly referrable to *Jania*, it has been found that the conceptacles not only are terminal and the branching dichotomous, but the genicula are unizonal, and the intergenicular medullary filaments are straight with cells in transverse zones of equal length. Consequently it seems proper not only to delimit *Jania* to species showing these essential characters but also to recognize its generic independence, since a definite line of demarcation can be drawn between it and any other genus of the articulated corallines.

Key to the species of Jania.

α^1. Fronds slender, 3 cm long, branching wholly dichotomous. 1. *J. rubens* (Linn.) Lamx.

α^2. Fronds large, 5 to 8 cm long; branching on lower parts dichotomous, on upper parts digitate..... 2. *J. digitata* Manza.

JANIA RUBENS (Linn.) Lamouroux.

Jania rubens (Linn.) LAMOUROUX, Nouv. Bull. Sci. Soc. Philomat. 3 (1812) 186.

Corallina rubens LINNÆUS, Syst. Nat. ed. 12 1 (1767) 1305.

Fronds slender, 3 cm long, in dense tufts; branching dichotomous-cymoid; intergenicula cylindrical, ultimate apices acute, approximately 0.5 to 0.75 mm long and 0.25 mm in diameter; conceptacles terminal, wholly or partially in cymoid clusters, terminal conceptacles mostly antenniferous, pores apical, and tetrasporangia basal.

Type.—*Corallina rubens* Linnæus.

Type locality.—"O. Europaeo."

Jania rubens (Linn.) Lamx. was first described by Linnæus (21, p. 1305) as *Corallina rubens*, as having dichotomous branching and cylindrical articuli with broader upper ends. According to Lamouroux (17, pp. 271–273) *Jania rubens* has terminal conceptacles borne singly or in "chaplets," with the ultimate conceptacles distinctly provided with one or two appendages; dichotomous branching; and cylindrical or club-shaped articuli. Areschoug (3, p. 557) described it as follows:

Fronde breviori caespitosa, axillis patentibus, ramis subarcuatis, articulis ramiferis subcuneatis, eramiferis cylindraceis, utrisque diametro 4 plo–6 plo longioribus, dichotomiis superioribus ultimisque keramidiferis, keramidiis urnaeformibus poro producto, cornibus subaequi-crassis.

In all these accounts of the species restriction no mention has even been made of the size of the plants. The Linnæan type specimen of *Jania rubens,* according to excellent photographs, is a very slender species. The branching is dichotomous in the vegetative parts with the divisions of long branches, but cymoid on the fruiting parts on account of the conceptacular antennæ of seemingly simple ramules becoming conceptacular in a seemingly unlimited fashion. The intergenicula are generally cylindrical, except those bearing branches in which they are slightly club-shaped. In addition, the apices of the ultimate segments are pointed.

A considerable number of additional species that can properly be referred to *Jania* have been described, but their designations are as yet to be ascertained. In addition we have at least one new South African species properly distinguished and described, namely:

JANIA DIGITATA Manza.

Jania digitata MANZA, Proc. Nat. Acad. Sci. U. S. A. 23 (1937) 571, 572.

Fronds 5 to 8 cm long; branching dichotomous-digitate-cymoid; intergenicula near base cylindrical, 1 to 2 mm long and 1 mm in diameter, on upper parts on primary branches cylindrical or slightly compressed, club-shaped, and on ultimate branchlets gradually becoming slender, cylindrical, 2 to 3 mm long and 1 to 1.5 mm broad; tetrasporic conceptacles terminal, in cymoid clusters, with ultimate conceptacles provided with 2 lateral proliferations, pores apical, and tetraspores basal.

Type: tetrasporic, *Herb. Univ. Calif. No. 564574;* Cape Peninsula, South Africa; Coll. Ecol. Surv. *F–123.*

4. Genus CORALLINA Linnæus (emend. Lamouroux)

Corallina LINNÆUS, Syst. Nat. ed. 12 pt. 2 1 (1767) 1304–1306; LAMOUROUX, Nouv. Bull. Sci. Soc. Philomat. 3 (1812) 185, 186, Hist. Polyp. Flex. (1816) 275–292.

Fronds fragile; branching wholly or partially pinnate; genicula unizonal; intergenicular medullary filaments straight with cells in transverse zones of equal length; conceptacles terminal on the apices of the ramules or short branches, with or without "antennæ."

The genus *Corallina* was used as early as 1719 by Tournefort,(31) in 1767 by Linnæus(21) and in 1786 by Ellis,(8) but the designations included not only the articulated corallines in gen-

eral but also many other calcareous algæ, such as species of *Halimeda*, species of *Galaxaura*, and even corals. Lamouroux, in the early part of the 19th century, however, limited the scope of the term *Corallina* to a restricted group of calcareous algæ that includes only, according to our interpretation, the articulated corallines (Corallineae verae Weber van-Bosse), so that the practical establishment of the genus may be rightfully attributed to him.

When *Corallina* was reformed by Lamouroux in 1812 he listed 3 species, *Corallina officinalis* Ell., *C. rosarium* Ell., and *C. loricata* Ell., but in 1816 he described 21 species, including, however, only 2 of his former species, *Corallina officinalis* and *C. loricata*. These 2 species were mentioned again among 9 others in 1842 by Decaisne.(6, pp. 119–122) Harvey in 1847(10, pp. 103, 104) described 5 species including *Corallina officinalis* and *C. loricata*. In 1852, however, Areschoug,(3, pp. 560–576) in describing 15 species, referred *C. loricata* and 8 others to *C. officinalis*, and Ardissone in 1883(2, pp. 462, 463) likewise recognized *C. loricata* with 2 other species as akin to *C. officinalis*. In 1897 Schmitz and Hauptfleisch(28, p. 543) listed under *Corallina, Corallina officinalis* Linn., *C. mediterranea* Aresch., and *C. rubens* Linn. Yendo,(38, pp. 1, 2, 27–37) who in 1905 listed 21 species, likewise referred *C. loricata* to *C. officinalis* and reduced several other species to forms of *C. officinalis*. Of these species *Corallina officinalis* Linn. may be adopted as the type. It was the first in the list of Lamouroux under the genus *Corallina*, and has since consistently been recognized as a typical *Corallina* by practically all authors.

The generic diagnosis of *Corallina* has undergone variations since Lamouroux, and different characters have been emphasized. Lamouroux in 1812 and in 1816 restricted the genus to species with pinnate branching. In 1842 Decaisne limited the genus to species with terminal nonantenniferous conceptacles and with pinnate branching, and referred all species with terminal antenniferous conceptacles with branching either pinnate or dichotomous to *Jania*. Harvey in 1847 seems to have followed the generic restriction of Decaisne. In 1852 Areschoug, and Yendo in 1905, referred to the genus all species with terminal conceptacles antenniferous or nonantenniferous, but with pinnate branching. In 1904 Weber van-Bosse(32, p. 86) made no definite statement of her concept of the genus *Corallina*, since she did not separate *Corallina* from *Jania* in her Synoptical Key to the

Genera of Corallineae verae, although she recognized by the binomials in her list (32, p. 107) the generic independence of these two genera. However, she definitely established the fact that in these two genera the conceptacles are terminal, the genicula unizonal, and the intergenicular medullary filaments straight with cells in transverse zones of equal length. In addition, she seemed to recognize that species of *Corallina* have pinnate branching, since she listed under this genus species only with pinnate branching.

The Linnæan type, of which we have excellent photographs, has terminal nonantenniferous conceptacles, and the branching is plumosely pinnate and opposite. It seems best, however, to unite those species having generally pinnate branching and terminal conceptacles in the genus *Corallina,* but since two sets of species are represented, (*a*) those with terminal nonantenniferous, and (*b*) those with terminal antenniferous conceptacles, it likewise seems best to establish two subgenera, *Eucorallina* and *Cornicularia.*

4a. Subgenus EUCORALLINA subgen. nov.

Fronds fragile; branching wholly or partially pinnate; genicula unizonal; intergenicular medullary filaments straight, with cells in transverse zones of equal length; conceptacles nonantenniferous, terminal on apices of ramules or short branches.

Species generis Corallinae conceptaculis nonantenniferis includens.

Species that have been described and are properly referable to *Eucorallina* have been collected thus far from Mediterranean shores, the coast of New Zealand, and the coast of Chile, suggesting that *Eucorallina* is restricted to temperate species.

Type species: *Corallina* (*Eucorallina*) *officinalis* Linnæus.

CORALLINA (EUCORALLINA) OFFICINALIS Linnæus. Plate 7, figs. 1 to 5.

Corallina officinalis ELL. in Linnæus, Syst. Nat. ed. 12 pt. 2 1 (1767) 1304.

Fronds erect, 3 to 4 cm long; branching plumosely bi- or tripinnate and opposite, the primary divisions of long branches once or twice divided, ultimate divisions of simple ramules; intergenicula near base cylindrical, 1 mm long, 1 mm in diameter and compressed on upper parts, on branches subcuneate and 1 mm long and 1 to 1.5 mm broad, on ramules linear or spathulate, 1 to 2 mm long and 0.5 mm broad; conceptacles terminal, nonantenniferous on apices of simple ramules, with pores apical and tetrasporangia basal.

Type: *Corallina officinalis* Linnæus in Herb. British Museum.

Type locality.—"O. Europeo, Mediterraneo."

Many descriptions of the type species have been given, but they have emphasized different characters. Linnæus (21, p. 1304) described it as a plant with pinnate branching and with subconical articuli. According to Lamouroux, (17, p. 283) it has bipinnate branching and cuneiform articuli. Decaisne (5, pl. 17, fig. 1, *c*) figured it as having nonantenniferous terminal conceptacles borne on the apices of the ramules. Harvey (10, p. 104) described it as having pinnate or bipinnate branching, with articuli cylindrical near the base and compressed near the tips. Areschoug (3, p. 562) limited it to plants with branching pinnate, pinnules simple, thick or subclavate; articuli on the primary portions compressed or subcompressed and cylindrical on the pinnules; conceptacles nonantenniferous, oval-subspherical, and provided with long pedicels. *Corallina officinalis* is a small species, about 4 cm high. The segments are slightly compressed except near the base. At times the primary branches near the base are made up of simple ramules, but in such cases they are few. The ramules which are the ultimate divisions of the branches are simple, being made up of basal genicula and unsegmented upper portions upon the apices of which the conceptacles may be borne. In other species of *Corallina* the stalks bearing the conceptacles are made up of a number of genicula and intergenicula.

There appear to be only 4 additional species (3, pp. 562–567) described that can be properly included under *Eucorallina:*

CORALLINA (EUCORALLINA) NANA Zanard.

Corallina (*Eucorallina*) *nana* ZANARD in Areschoug, J. G. Agardh, Sp. Alg. pt. 2 2 (1852) 564, 565.

CORALLINA (EUCORALLINA) CHILENSIS Decaisne.

Corallina (*Eucorallina*) *chilensis* DECAISNE in Harvey, Ner. Austr. (1847) 103; ARESCHOUG in Agardh, Sp. Alg. pt. 2 2 (1852) 565, 566.

Corallina officinalis var. *chilensis* YENDO, Journ. Coll. Sci. Imp. Univ. Tokyo Art. 12 20 (1905) 30.

CORALLINA (EUCORALLINA) BERTERI Mont.

Corallina (*Eucorallina*) *Berteri* MONT. in Harvey, Ner. Austr. (1847) 103; ARESCHOUG in Agardh, Sp. Alg. pt. 2 2 (1852) 566; YENDO, Journ. Coll. Sci. Imp. Univ. Tokyo Art. 12 20 (1905) 31.

CORALLINA (EUCORALLINA) ARMATA Hooker f. et Harvey.

Corallina (*Eucorallina*) *armata* HOOKER f. et HARVEY in Harvey, Ner. Austr. (1847) 103; ARESCHOUG in Agardh, Sp. Alg. pt. 2 2 (1852) 566–567; YENDO, Journ. Coll. Sci. Imp. Univ. Tokyo Art. 12 20 (1905) 31.

The species of *Eucorallina* may be recognized easily by the position and character of the conceptacles and by the mode of branching, such as: conceptacles terminal and nonantenniferous, branching pinnate. These species, *Corallina* (*Eucorallina*) *nana*, *C.* (*E.*) *chilensis*, *C.* (*E.*) *Berteri*, and *C.* (*E.*) *armata*, are listed by Areschoug(3) under his species of *Corallina* with conceptacles terminal and nonantenniferous, and with branching pinnate. The specimens which have been referred to those species, which have been studied also, have the conceptacles terminal and nonantenniferous, and the branching pinnate, so that they may be referred properly to species of *Eucorallina* as restricted. Unfortunately, however, available specimens of these species do not lend themselves to accurate specific description, so that it seems proper, at present, merely to list them under *Eucorallina*.

4b. Subgenus CORNICULARIA Manza

Cornicularia MANZA, Proc. Nat. Acad. Sci. U. S. A. (2) 23 (1937) 47.

Fronds fragile; branching wholly or partially pinnate; geniculа unizonal; intergenicular medullary filaments straight, with cells in transverse zones of equal length; conceptacles terminal on apices of simple ramules or short branches, entirely or mostly antenniferous.

Species generis Corallinae conceptaculis antenniferis includens.

Type species: *Corallina* (*Cornicularia*) *gracilis* Lamouroux.

Species that have been described and that can properly be included under subgenus *Cornicularia*, have been collected, thus far, from subtropical and tropical shores: The coast of Alexandria; Akaroa Island, New Zealand; King George Sound, western Australia; Tasmania; Port Natal, Brazil.

The presence of the so-called horns (conceptacular antennæ) separates the species of *Cornicularia* from those of *Eucorallina*, and the mode of branching (wholly or partially pinnate in *Cornicularia*) separates *Cornicularia* from *Jania* (strictly dichotomous or dichotomous-cymoid in *Jania*). Trevisan, according to Yendo,(39) remarks that "the presence of the horns upon the

conceptacles never offers constant characters," giving the impression that the presence or absence of horns may be variable in the same species. My own observations of a considerable number of species under natural conditions seem to indicate that horns or antennæ are specific characters rather than variables, since in no case were antenniferous conceptacles found in species normally with nonantenniferous conceptacles, although collections were made from a wide range of conditions, while in those normally with antenniferous conceptacles the latter are present in great abundance.

Under *Cornicularia* may be included a number of species previously referred to *Jania* but with pinnate branching,(6, p. 111) such as *Jania elegans* Decne., *J. Cuvieri* (Lamx.) Decne., *J. paniculata* (Lamx.) Decne., *J. crispata* (Lamx.) Decne., *J. rosea* (Lamx.) Decne.,(10, pp. 105, 106) *J. Hombronii* Mont., *J. pistillaris* Mont., *J. gracilis* Mont., and *J. subulata* Sond., as well as a number of species generally referred to *Corallina* whose individuals are largely if not entirely provided with antenniferous conceptacles;(3, pp. 567–574) such as *Corallina squamata* Ell. et Sol., *C. mediterranea* Aresch., *C. elegans* Linorm., *C. subulata* Ell. et Sol., *C. pilifera* Lamx., *C. Cuvieri* Lamx., *C. rosea* Lamx., *C. Hombronii* Mont., and *C. pistillaris* Mont.

Type specimens were not available for examination, but Lamouroux(17, p. 288, pl. 10, fig. 1, *a*, *b*) gives fairly good accounts of the species. According to his description and illustrations, the characters of the plants available for study agree with those indicated for the type. In 1847 Harvey(10, pp. 105, 106) referred it to *Jania gracilis* Mont. In 1852 Areschoug(3, p. 272) referred it, with some doubt, to *Corallina Cuvieri* Lamx., while in 1905 Yendo(38, p. 36) reduced it to a species inquirenda of the genus *Corallina*. *Corallina* (*Cornicularia*) *gracilis* has pinnate branching, so that it cannot consistently be referred to *Jania* if the generic restriction indicated elsewhere in this paper is applicable. *Corallina Cuvieri* Lamouroux,(17, pp. 286, 287, pl. 9, fig. 8, *a*, *b*) the main branching of which is pinnate and opposite, has the ramules divided dichotomously, while *Corallina* (*Cornicularia*) *gracilis* Lamouroux has the main branching pinnate and opposite but with simple ramules, with no dichotomies anywhere, so that it seems proper to recognize their specific entities.

CORALLINA (CORNICULARIA) GRACILIS Lamouroux.

Corallina (*Cornicularia*) *gracilis* LAMOUROUX, Hist. Polyp. Flex. (1816) 288, pl. 10, fig. 1, *a*, *b*.

Fronds erect, dark purple, 6 to 9 cm long; branching plumosely pinnate-tripinnate and opposite, primary divisions of simple ramules and long branches once or twice pinnately divided, ultimate divisions of simple ramules, generally with ramules opposite ramules and branches opposite branches; intergenicula near base cylindrical, 1 mm long, about 0.75 mm in diameter, subcompressed, subcuneate, 1 mm long, about 0.5 mm broad or less on upper parts on primary branches, cylindrical and very slender on ramules; conceptacles terminal on apices of ramules, mostly with two lateral antennæ.

Type: *Corallina gracilis* Lamouroux.

Type locality.—"Australasie."

Although a considerable number of described species of *Cornicularia* have been placed under the genus *Corallina* because of their terminal conceptacles, (3, pp. 567–574; 17, pp. 275–292; 38, pp. 27–41) or else under *Jania* because the conceptacles are terminal and antenniferous, (6, p. 111; 10, pp. 104–106) a large number of these described species must await further study. It seems best, at present, to refer only the following 9 additional species under the subgenus *Cornicularia:*

CORALLINA (CORNICULARIA) MEDITERRANEA Areschoug.

Corallina (*Cornicularia*) *mediterranea* ARESCHOUG in J. G. Agardh, Sp. Alg. pt. 2 2 (1852) 568, 569.

CORALLINA (CORNICULARIA) CUVIERI Lamouroux.

Corallina (*Cornicularia*) *cuvieri* LAMOUROUX, Hist. Polyp. Flex. (1816) 286–287, pl. 9, fig. 8, *a*, *b*.

Jania Cuvieri (Lamx.) DECAISNE, Mem. sur les Corallines (1842) 111; HARVEY, Ner. Austr. (1847) 105.

Corallina cuvieri LAMX., Areschoug in J. A. Agardh, Sp. Alg. pt. 2 2 (1852) 572, 573; KUETZING, Tab. Phyc. 8 (1858) 33, pl. 70, fig. 1, *a–g;* YENDO, Journ. Coll. Sci. Imp. Univ. Tokyo Art. 12 20 (1905) 35.

CORALLINA (CORNICULARIA) ROSEA Lamarck.

Corallina (*Cornicularia*) *rosea* LAMARCK, Mem. du Mus. (1815) 232.

Jania Cuvieri (Lamx.) DECAISNE, Mem. sur les Morallines (1842) 111; HARVEY, Ner. Austr. (1847) 105, pl. 40, figs. 1–3.

Corallina rosea LAMX., Areschoug in J. A. Agardh, Sp. Alg. pt. 2 2 (1852) 573, 574; KUETZING, Tab. Phyc. 8 (1838) 34, pl. 72, fig. 2, *c–e;* YENDO, Journ. Coll. Sci. Imp. Univ. Tokyo Art. 12 20 (1905) 35.

CORALLINA (CORNICULARIA) SUBULATA (Sond.) Ellis.

Corallina (*Cornicularia*) *subulata* (Sond.) ELLIS, Cor. (1755) 120, pl. 21, figs. *b*, *c*.

Jania subulata SONDER in Harvey, Ner. Austr. (1847) 106, pl. 40, figs. 1–4.

Corallina subulata ELLIS, Areschoug in J. G. Agardh, Sp. Alg. pt. 2 2 (1852) 570, 571; YENDO, Journ. Coll. Sci. Imp. Univ. Tokyo Art. 12 20 (1905) 35.

CORALLINA (CORNICULARIA) VIRGATA Zanardini.

Corallina (*Cornicularia*) *virgata* ZANARDINI in Kuetzing, Tab. Phyc. 8 (1858) 36, pl. 76, fig. 2 *d–g*; YENDO, Journ. Coll. Sci. Imp. Univ. Tokyo Art. 12 20 (1905) 30.

CORALLINA (CORNICULARIA) CERATOIDES Kuetzing.

Corallina (*Cornicularia*) *ceratoides* KUETZING, Tab. Phyc. 8 (1858) 36, pl. 75, fig. 2, *c*, *d*.

CORALLINA (CORNICULARIA) TRICHOCARPA Kuetzing.

Corallina (*Cornicularia*) *trichocarpa* KUETZING, Tab. Phyc. 8 (1858) 35, pl. 74, fig. 1, *a*, *b*; YENDO, Journ. Coll. Sci. Imp. Univ. Tokyo Art. 12 20 (1905) 35.

CORALLINA (CORNICULARIA) PILIFERA Lamouroux.

Corallina (*Cornicularia*) *pilifera* LAMOUROUX, Hist. Polyp. Flex. (1816) 289, 290; KUETZING, Tab. Phyc. 8 (1858) 35, pl. 74, fig. 2, *c*, *d*; YENDO, Journ. Coll. Sci. Imp. Univ. Tokyo Art. 12 20 (1905) 35.

CORALLINA (CORNICULARIA) DENUDATA Sonder.

Corallina (*Cornicularia*) *denudata* SONDER in Kuetzing, Tab. Phyc. 8 (1858) 34, pl. 73, fig. *a–c*.

Corallina Cuvieri fo. *denudata* YENDO, Journ. Coll. Sci. Imp. Univ. Tokyo Art. 12 20 (1905) 35.

Of *Corallina* (*Cornicularia*) *mediterranea* we have merely fragments of the segments; of the other species, *Corallina* (*Cornicularia*) *cuvieri*, *C.* (*C.*) *rosea*, *C.* (*C.*) *subulata*, *C.* (*C.*) *virgata*, *C.* (*C.*) *ceratoides*, *C.* (*C.*) *trichocarpa*, *C.* (*C.*) *pilifera*, and *C.* (*C.*) *denudata*, Kuetzing(14) provides fair illustrations of the characters of the fronds. According to the figures of Kuetzing, and judging by the specimens referred to those species, they all belong to *Cornicularia* as the subgenus is restricted; such as branching pinnate, and conceptacles terminal and antenniferous. As we have no suitable specimens of these species for proper description, and as the types were not available for study, they are merely listed under *Cornicularia*.

5. Genus ARTHROCARDIA Decaisne (emend. Areschoug)

Arthrocardia DECAISNE, Class. des Algues (1842) 63, pl. 17, fig. 8; Mem. sur. less Corallines (1842) 112, 113 (*nomen nudum*); ARESCHOUG in J. G. Agardh, Sp. Alg. pt. 2 2 (1852) 547–553.

Fronds fragile; branching pinnate-cymoid; genicula unizonal; intergenicular medullary filaments straight, with cells in transverse zones of equal length; conceptacles terminal and in cymoid clusters, upright or with pores apical.

Type species: *Arthrocardia corymbosa* (Lamk.) Decaisne.

There are, at present, only 8 additional species that can properly be referred to *Arthrocardia*, all of which have been collected from South Africa, suggesting that the species of this genus are not only strictly temperate but exclusively South African.

The genus *Arthrocardia* was first proposed in 1842 by Decaisne, who cited 3 species, *Arthrocardia sagittata* Decne., *Arthrocardia corymbosa* (Lamk.) Decne., and *Arthrocardia prolifera* Decne. In the same year he reduced *Arthrocardia* to a subgenus of *Amphiroa* and listed under it *Amphiroa* (*Arthrocardia*) *corymbosa* (Lamk.) Decne., *Amphiroa* (*Arthrocardia*) *orbigniana* Decne., *Amphiroa* (*Arthrocardia*) *vertebralis* Decne., *Amphiroa* (*Arthrocardia*) *californica* Decne., *Amphiroa* (*Arthrocardia*) *Chiloensis* Decne., and *Amphiroa* (*Arthrocardia*) *prolifera* (Lamx.) Decne., but he referred his *Arthrocardia sagittata* to his *Amphiroa* (*Cheilosporum*) *sagittata*, emphasizing the flattened obcordate intergenicula and conical conceptacles only for his *Arthrocardia*. In 1847 Harvey(10, pp. 99, 100) reduced *Arthrocardia* to a section of *Amphiroa*, referring to it *Amphiroa corymbosa* Decne., *A. Darwinii* Harvey, *A. Mallardiae* Harvey, *A. orbigniana* Decne., and *A. Chiloensis* Decne., and restricting it to species with flattened obcordate intergenicula and conical conceptacles scattered over the flat surfaces of the intergenicula. In 1852 Areschoug elevated *Arthrocardia* to an independent genus, emphasizing the terminal position of the conceptacles, and included under it 5 species, *Arthrocardia frondescens* (P. et R.) Aresch., *Arthrocardia palmata* (Ell. et Sol.) Aresch., *Arthrocardia corymbosa* (Lamk.) Decne., *Arthrocardia Wardii* (Harvey) Aresch., and *Arthrocardia Mallardiae* (Harvey) Aresch. In 1897 Schmitz and Hauptfleisch(28, p. 543) referred *Arthrocardia* as a synonym under *Cheilosporum*, but likewise emphasized the fact that the conceptacles are terminal. In

1904 Weber van-Bosse (32, pp. 86, 105, 106) recognized the generic rank of *Arthrocardia* but cited no species of *Arthrocardia* described by Areschoug, and stated that the conceptacles are scattered over the surfaces of the intergenicula. Consequently the *Arthrocardia* of Weber van-Bosse seems to include largely or entirely species like *Arthrocardia cretacea* (P. et R.) Weber van-Bosse, *Arthrocardia tuberculosa* (P. et R.) Weber van-Bosse, *Arthrocardia variabilis* (Yendo) Weber van-Bosse, *Arthrocardia epiphlegnoides* (Ag.) Weber van-Bosse, *Arthrocardia eberrans* (Yendo) Weber van-Bosse, *Arthrocardia declinata* (Yendo) Weber van-Bosse, *Arthrocardia Darwinii* (Harvey) Weber van-Bosse, *Arthrocardia vertebralis* (Decne.) Weber van-Bosse, and *Arthrocardia breviarticulata* (Aresch.) Weber van-Bosse, not conforming to Areschoug's idea but only to the more general composite idea of Decaisne. (6, pp. 112, 113) In 1905 Yendo (33, pp. 1, 7, 9) reduced *Arthrocardia* again to a section of *Amphiroa*, but his section includes *Amphiroa corymbosa* (Lamk.) Decne., *A. Wardii* Harvey, and *A. Mallardiae* Harvey, all species of *Arthrocardia* in the sense of Areschoug, and described *A. aberrans* Yendo.

The genus *Arthrocardia* as treated by various writers since Decaisne, who named it, includes at least 3 categories of species: (*a*) species with conceptacles strictly terminal, arising from the apical meristem, illustrated by *Arthrocardia corymbosa* (Lamk.) Decne., and its probable synonym *Arthrocardia prolifera* (Lamx.) Decne.; (*b*) species with conceptacles lateral, but adaxially marginal in the hornlike projections of the intergenicula, represented by *Arthrocardia sagittata* (Lamx.) Decne., later chosen as the type of the *Cheilosporum* section of *Amphiroa* by Decaisne in his original list of species of *Arthrocardia* and logically the type of the genus *Cheilosporum* in Areschoug's arrangement; (*c*) species with lateral conceptacles on the flattened surfaces or margins of the intergenicula, such as *Amphiroa* (*Arthrocardia*) *orbigniana* Decne., and *Amphiroa* (*Arthrocardia*) *vertebralis* Decne. Since it seems imperative to delimit the genus to one of these categories; since *Arthrocardia corymbosa* (Lamk.) Decne. was mentioned first, and likewise figured by Decaisne; and since it includes *Arthrocardia prolifera* (Lamx.) Decne. as a probable synonym, *Arthrocardia corymbosa* (Lamk.) Decne. may be designated the type species of the genus, and the genus delimited in accordance with the more general characteristics of the type species. This delimitation

seems to be in accordance with the ideas of Areschoug, who limited the genus to include only species with flattened joints and terminal conceptacles.

Although Decaisne proposed the genus *Arthrocardia* without generic diagnosis, his figure leads to the inference that the genus at least includes species with branching pinnate-cymoid; genicula unizonal; intergenicular medullary filaments straight, with cells in transverse zones of uniform length; conceptacles terminal, practically if not technically exact, since they are situated on the apical meristematic portions of the segments, and the axis upon which they are situated becomes determinate through the cessation of the meristematic activity. When Decaisne reduced *Arthrocardia* to a subgenus of *Amphiroa*, however, (6, pp. 112, 113) he seemed to include under the subgenus all species with segments compressed-obcordate and with conceptacles conical. As a section of *Amphiroa*, Harvey (10, pp. 99, 100) limited it in the same fashion as did Decaisne. Areschoug (3, p. 547) restricted the genus *Arthrocardia* to species with terminal conceptacles, apparently recognizing *Arthrocardia* as the type. Schmitz and Hauptfleisch (28, p. 543) likewise indicated that in *Arthrocardia* the conceptacles are terminal, although they placed *Arthrocardia* as a synonym under *Cheilosporum*. Weber van-Bosse, (32, p. 86) who restored the generic rank of *Arthrocardia*, made the following limitation: plants with conceptacles forming conical protuberances on the faces of the "joints," nodes consisting of one row of cells, all the cells in the central strand having the same dimension throughout. Yendo, (38, p. 1) who reduced *Arthrocardia* to a section of *Amphiroa*, limited it in a fashion similar to the generic limitation proposed by Weber van-Bosse. As may be noticed in the foregoing, writers vary in their restrictions of *Arthrocardia* as a genus, subgenus, or as a section of *Amphiroa*, due possibly to their failure to establish the type and to base their limitation upon the type and related species.

Opinion still varies with regard to the exact position of the conceptacles in *Arthrocardia*. Decaisne in his earlier paper (5) practically but not technically holds the view that the conceptacles are terminal at least in his species, since his figure shows that the conceptacles in *Arthrocardia corymbosa* Decne. and *Arthrocardia prolifera* Decne. are at least on the apices of the intergenicula. In his later paper, where he treats *Arthrocardia* as a subgenus of *Amphiroa*, he seems to include the positions of the conceptacles as lateral, scattered over the surfaces

of the intergenicula, since he cites also *Amphiroa* (*Arthrocardia*) *orbigniana* Decne., *A.* (*Arthrocardia*) *californica* Decne., *A.* (*Arthrocardia*) *vertebralis* Decne., and other species with conceptacles typically lateral and scattered over the surfaces of the intergenicula. Areschoug emphatically states that the conceptacles are terminal on the apices of the intergenicula. Although Schmitz and Hauptfleisch definitely state that the conceptacles in *Arthrocardia* are terminal, they were not consistent in drawing any definite line of demarcation between terminal conceptacles and lateral conceptacles, since they interpret the conceptacles in *Cheilosporum* as being terminal. In *Cheilosporum,* according to the type *Cheilosporum sagittatum* (Lamx.) Areschoug, although the conceptacles are obliquely borne on the inner surfaces of the margins of the upper lobes of the intergenicula, they are lateral, since they spring from the inner margins of the projections of the intergenicula, and arise from the seemingly matured tissue in almost similar fashion as those of *Amphiroa* and *Bossea.* In *Arthrocardia,* as exemplified in the type, *Arthrocardia corymbosa* (Lamk.) Decne., the conceptacles arise directly from the apical meristem, develop vertically, and in their development the entire central cylinder of the apical meristem is used up, terminating any further vertical development of the segments from which they spring. Moreover, in all species of *Arthrocardia* the conceptacles produce generally two lateral branches equatorially and opposite, and each of these, in turn, produces conceptacles on its apices, in a fashion similar to that in certain species of *Jania.* This process is repeated a number of times, resulting in the formation of a system of branching here called, for convenience, cymoid branching. In the type, *Arthrocardia corymbosa* (Lamk.) Decne., and species properly distinguished as species of *Arthrocardia,* not only are the conceptacles terminal and the branching pinnate-cymoid, but the genicula are unizonal and the intergenicular medullary filaments straight with cells in transverse zones of equal length, so that it seems best not only to restrict *Arthrocardia* to species showing those essential characters, but likewise to recognize its independent generic rank.

Key to the species of Arthrocardia.

a^1. Fronds with slender proliferations.
b^1. Slender proliferations compressed..... 1. *A. Gardneri* Manza.
b^2. Slender proliferations more or less cylindrical.
c^1. Fronds with linear segments on branches.
2. *Arthrocardia linearis* Manza.

c^2. Fronds without linear segments..... 3. *A. attenuata* **Manza.**
a^2. Fronds without slender proliferations.
b^1. Fronds with wholly or partially thick segments.
c^1. Fronds with thick segments throughout.
4. *A. corymbosa* (Lamk.) Decne.
c^2. Fronds with basal segments slender, thick on upper parts.
5. *A. Papenfussii* **Manza.**
b^2. Fronds with segments thin.
c^1. Fronds with branches of simple ramules.... 6. *A. Setchelliae* **Manza.**
c^2. Fronds without branches of simple ramules.
d^1. Segments with pronounced midrib..... 7. *A. Stephensonii* **Manza.**
d^2. Segments without pronounced midrib..... 8. *A. Setchellii* **Manza.**

ARTHROCARDIA CORYMBOSA (Lamk.) Decaisne.

Corallina corymbosa LAMARCK, Animaux sans Vertebres 2 (1816) 331.
Amphiroa (Arthrocardia) corymbosa (Lamk.) HARVEY, Ner. Austr. (1847) 99; YENDO, Journ. Coll. Sci. Imp. Univ. Tokyo Art. 12 20 (1905) 7.
Arthrocardia corymbosa DECAISNE, Class. des Algues (1842) 63, pl. 17, fig. 8.

Fronds pinnate-cymoid; intergenicula near base cylindrical, on upper parts compressed-cuneate, 1 to 1.5 mm long and 1 to 2 mm broad and ultimately becoming slender; conceptacles terminal, in cymoid clusters, upright or with pores apical and with tetrasporangia basal.

Type: *Corallina corymbosa* Lamarck.

Type locality.—"ad littora Americae," fide Lamarck; "ad oram Capensem praesertem in sinu Tabulari nec non Algoensi non infrequenter," fide Areschoug.

Arthrocardia corymbosa (Lamk.) Decne. was first described as *Corallina corymbosa* Lamarck, with corymbose branching; basal articuli short, cylindrical, and on the upper parts compressed, cuneiform-sagittate. According to Areschoug, (3, pp. 550, 551) *Arthrocardia corymbosa* has cylindrical segments near the base, compressed on the upper parts, sublinear or ovate-cuneate, with the terminal segments becoming sublinear. The fragments of the type specimen, made available through the courtesy of the authorities of the Musée d'histoire Naturelle, has comparatively thick segments, seemingly cylindrical near the base, compressed-cuneate on the primary branches, ultimately becoming slender. The conceptacles are terminal on the apices of the intergenicula in cymoid clusters, upright or with pores apical and tetrasporangia basal.

Arthrocardia corymbosa is similar in general habit to species of *Duthiea*, differing from the latter only in the position of the

pores of the conceptacles, which are apical in species of *Arthrocardia* and slightly lateral in species of *Duthiea*.

While a fair number of South African species described originally under *Amphiroa* seem referrable to *Arthrocardia* when fertile specimens are examined, there are only 8 other species described at present which may be referable to this genus:

ARTHROCARDIA FLABELLATA (Kuetz.) comb. nov.

Corallina flabellata KUETZING, Tab. Phyc. 8 (1858) 29, pl. 60, fig. 2.

The type is not available for study, but fragments of species showing essential characters were examined. From the study of these fragments, and from available records, the species shows essential characters of *Arthrocardia* and not of species of *Corallina* to which it has been previously referred. On this account, and due to the fact that this species appears different from any species of *Arthrocardia* thus far known, it seems best not only to recognize its specific independence but likewise to recognize it as a species of the *Arthrocardia*.

ARTHROCARDIA ATTENUATA Manza.

Arthrocardia attenuata MANZA, Proc. Nat. Acad. Sci. U. S. A. 23 (1937) 568.

Fronds 4 to 6 cm long; branching on vegetative parts bi- or tripinnate, branches subalternate, on fruiting parts cymoid; intergenicula near base cylindrical, 1 to 2 mm long and 1 to 2 mm broad, on upper parts on primary branches compressed-cuneate or obcordate, lobes acute, 2 mm long and 2 mm broad, on ultimate branchlets becoming filiform; tetrasporic conceptacles terminal in cymoid clusters, pores apical.

Type: tetrasporic, *Herb. Univ. Calif. No. 548786;* Sea Point, South Africa. Collected by A. V. Duthie.

ARTHROCARDIA GARDNERI Manza.

Arthrocardia Gardneri MANZA, Proc. Nat. Acad. Sci. 23 (1937) 568.

Fronds 4 to 6 cm long; branching on vegetative parts bi- or tripinnate and opposite, with long branches once or twice divided, on fruiting parts cymoid; segments near base thick, gradually becoming slender downward, intergenicula cylindrical, 1 to 2 mm long and 1 to 2 mm broad, on upper parts compressed, intergenicula on primary branches obovate, obcordate, or spathulate, 2 to 4 mm long and 2 to 3 mm broad, on ultimate branchlets becoming gradually slender; tetrasporic conceptacles terminal, in cymoid clusters, pores apical.

Type: tetrasporic, *Herb. Univ. Calif. No. 565485;* Isipingo Beach, Natal, South Africa. Collected by Ecol. Surv. *D. C. 11.*

ARTHROCARDIA LINEARIS Manza.

Arthrocardia linearis MANZA, Proc. Nat. Acad. Sci. 23 (1937) 569.

Fronds 3 to 8 cm long; branching on vegetative parts pinnate and opposite, long branches once or twice divided, ultimate divisions composed of simple, slender ramules, on the fruiting parts cymoid; segments near the base cylindrical, intergenicula 1 to 3 mm long and 1 to 1.5 mm broad, on upper parts compressed, intergenicula of primary branches obcordate, lobes obtuse, 2 to 3 mm long and 2 to 3 mm broad, on branchlets sublinear, 3 to 6 mm long and 1 mm broad, at times becoming filiform; tetrasporic conceptacles terminal, in cymoid clusters, pores apical.

Type: tetrasporic, *Herb. Univ. Calif. No. 564560;* Isipingo Beach, Natal, South Africa. Collected by Ecol. Surv. *D. C. 3.*

ARTHROCARDIA PAPENFUSSII Manza.

Arthrocardia Papenfussii MANZA, Proc. Nat. Acad. Sci. 23 (1937) 569.

Fronds 3 to 5 cm long; branching on vegetative parts pinnate to pinnate-decompound and opposite, long branches once or twice pinnately divided, ultimate divisions consisting of simple ramules, on fruiting parts cymoid; segments near base becoming gradually becoming slender downward, intergenicula cylindrical, 2 to 3 mm long and 1 to 1.5 mm broad, on upper parts on primary branches compressed-cuneate, 2 mm long and 2 to 3 mm broad, on ramuli slightly compressed, subclavate, 3 mm long and 1 to 1.5 mm broad; conceptacles terminal, in cymoid clusters, pores apical.

Type: tetrasporic, *Herb. Univ. Calif. No. 564568;* Collected by G. F. Papenfuss *No. 50;* cystocarpic, *Herb. Univ. Calif. No. 564583;* G. F. Papenfuss *No. 50–A;* Melkbosch, South Africa.

ARTHROCARDIA SETCHELLIAE Manza.

Arthrocardia Setchelliae MANZA, Proc. Nat. Acad. Sci. 23 (1937) 569, 570.

Fronds 3 to 4 cm long; branching on vegetative parts plumosely pinnate to tripinnate and opposite, primary branches long, once or twice divided, ultimate divisions composed of simple ramules, on fruiting parts cymoid; segments near base gradually becoming filiform downward; on upper parts compressed, inter-

genicula on primary branches thick, cuneate-obovate, 2 mm long and 1 mm broad; tetrasporic conceptacles terminal, mostly in cymoid clusters, rarely terminal on simple ramules, pores apical.

Type: tetrasporic, *Herb. Univ. Calif. No. 564557;* Witsands, South Africa. Collected by G. F. Papenfuss *No. 57.*

ARTHROCARDIA SETCHELLII Manza.

Arthrocardia Setchellii MANZA, Proc. Nat. Acad. Sci. 23 (1937) 570.

Fronds 3 to 5 cm long; branching on vegetative parts pinnate and opposite or pinnate-decompound, long branches once or twice divided, short branches composed of simple ramules, on fruiting parts cymoid; segments near base tapering downward, intergenicula slightly compressed or cylindrical, 1 mm long and 2 to 3 mm broad, on upper parts compressed-obcordate, lobes obtuse, rarely acute, 2 mm long and 2 to 3 mm broad; tetrasporic conceptacles terminal, in cymoid clusters, rarely on apices of simple ramules, pores apical.

Type: tetrasporic, *Herb. Univ. Calif. No. 564553;* Port Nolloth, South Africa. Collected by Ecol. Surv. *P. N. C. 5.*

ARTHROCARDIA STEPHENSONII Manza.

Arthrocardia Stephensonii MANZA, Proc. Nat. Acad. Sci. 23 (1937) 570.

Fronds 2 to 4 cm long; branching on vegetative parts pinnate and opposite or pinnate-decompound, on fruiting parts cymoid; segments near base filiform, on upper parts compressed, lobes acute, rarely obtuse, 1 to 2 mm long and 1 to 2 mm broad; tetrasporic conceptacles terminal, in cymoid clusters, pores apical.

Type: tetrasporic, *Herb. Univ. Calif. No. 564581;* St. James, Cape Peninsula, South Africa. Collected by Ecol. Surv. *F–121.*

Genus DUTHIEA Manza

Duthiea MANZA, Proc. Nat. Acad. Sci. U. S. A. (2) 23 (1937) 48.

Fronds fragile; branching pinnate-cymoid (branching in vegetative stages pinnate, in fruiting stages cymoid); segments near base cylindrical or compressed, on upper parts compressed; genicula unizonal; intergenicular medullary filaments straight, with cells in transverse zones of equal length; conceptacles terminal in cymoid clusters, with pores slightly lateral or slightly below apices of segments.

Type species: *Duthiea Setchellii* Manza.

Thus far only the type species is known in this genus, *Duthiea Setchellii,* specimens of which have thus far been collected only

by Dr. A. V. Duthie, from Blauwklip, South Africa. In general habit species of *Duthiea* and of *Arthrocardia* are very closely similar, both having the branching pinnate in the vegetative portions but cymoid in the fruiting parts, with the conceptacles borne in similar positions in each genus. The two genera differ merely in the positions of the pores of the conceptacles. Relative to the apices of the segments on which they are borne, the pores in *Duthiea* are distinctly below the apices of the conceptacles, while in *Arthrocardia* they are strictly terminal. On account of the positions of the pores, the conceptacles in *Duthiea* could be described as lateral, since they are partially or wholly on the flat surfaces of the intergenicula. In our discussion in connection with the conceptacles, however, attention was called to the fact that the so-called terminal conceptacles originate from the apical meristem, and in their developments the apical meristem is wholly or partially transformed, while the so-called lateral conceptacles of the other genera originate from the seemingly mature tissue of the intergenicula. In *Duthiea* the conceptacles are developed from the apical meristem, and in their development the entire central meristematic cylinder of the apical meristem is involved, so that the conceptacles may properly be called terminal. This peculiar position of the conceptacular pores in *Duthiea* is due merely to the conceptacles themselves developing obliquely or slightly sideways instead of upright or parallel to the axis of the segments upon which they are borne. I have stated that in species of *Corallina* (*Cornicularia*) most of the conceptacles are antenniferous or provided with lateral proliferations of varying number, depending on the species. In *Duthiea* and in *Arthrocardia*, as well as in most species of *Jania*, these conceptacular antennæ, normally two, borne one opposite the other, become conceptacular and become, in turn, antenniferous in the same fashion as in the one from which they spring. The repetition of this process results in the determinate type of branching, which in this account is called cymoid branching to differentiate this sympodial from monopodial indeterminate branching which is normal to all strictly pinnate species.

DUTHIEA SETCHELLII Manza. Plate 8, figs. 1 and 2.

Duthiea Setchellii MANZA, Proc. Nat. Acad. Sci. U. S. A. (2) 23 (1937) 48.

Fronds erect, 4 to 6 cm long; branching in vegetative parts pinnate or tripinnate and opposite, on fruiting parts cymoid; intergenicula near base cylindrical, 1 to 2 mm long and 1 to 2

mm in diameter, on upper parts compressed-cuneate or obcordate, with lobes obtuse, 2 mm long and 2 to 3 mm broad; conceptacles terminal, in cymoid clusters, oblique or with pores slightly below apices of segments, tetrasporangia borne on base and along wall of conceptacular cavity. Cystocarpic and antheridial plants unknown.

Type: Tetrasporic, Blauwklip, near the mouth of Grote River, South Africa (*Herb. Univ. Calif. No. 545765; Duthie No. 8012 in Herb. Univ. Calif.*).

Duthiea Setchellii is similar to *Arthrocardia corymbosa* in general habit, but differs from the latter in the position of the pores of the conceptacles, this being slightly lateral in *Duthiea Setchellii* and absolutely terminal in *Arthrocardia corymbosa* as well as in all other species of *Arthrocardia*. Moreover, in *Duthiea Setchellii* the tetrasporangia spring not only from the bases of the conceptacles but likewise from along the lateral walls of the conceptacular cavity, while in *Arthrocardia corymbosa* the tetrasporangia are borne strictly on the bases of the conceptacles.

7. Genus CHEILOSPORUM Areschoug

Cheilosporum ARESCHOUG in J. G. Agardh, Sp. Alg. p. 2 2 (1852) 543–547.

Fronds fragile; branching wholly or partially dichotomous; genicula unizonal; intergenicular medullary filaments straight, cells in transverse zones of equal length; conceptacles restricted on upper margins of upper lobes of intergenicula.

Type species: *Cheilosporum sagittatum* (Lamx.) Areschoug.

Species of *Cheilosporum* seem to have a very extensive range of distribution, specimens being collected from temperate and tropical shores, Île-de-France, the coast of Brazil, Cape of Good Hope, Mauritius Islands, and Java.

Cheilosporum was treated first as a subgenus of *Amphiroa* by Decaisne, who listed 4 species, *Amphiroa* (*Cheilosporum*) *sagittata* (Lamx.) Decne., *A.* (*Cheilosporum*) *acutiloba* Decne., *A.* (*Cheilosporum*) *Lamourouxiana* (Leach) Decne., and *A.* (*Cheilosporum*) *fastigiata* Decne. Harvey (10, pp. 101, 102) treated *Cheilosporum* as a section of *Amphiroa* and described under it 7 species, including *Amphiroa sagittata* Decne. Areschoug elevated *Cheilosporum* to an independent genus and described under it 6 species, *Cheilosporum stangeri* (Harvey) Aresch., *Cheilosporum flabellatum* (Harvey) Aresch., *Cheilosporum sagittatum* (Lamx.) Aresch., *Cheilosporum cultratum* (Harvey) Aresch.,

Cheilosporum elegans (Hook. fil. et Harvey) Aresch., and *Cheilosporum jungermannioides* (Rupr.) Aresch., but reduced *Amphiroa* (*Cheilosporum*) *acutiloba* Decne. to a species inquirenda. Schmitz and Hauptfleisch (29, p. 543) recognized the generic rank of *Cheilosporum*, and definitely established *Cheilosporum sagittatum* (Lamx.) Areschoug as the type species. They, however, placed *Arthrocardia* under *Cheilosporum* as a synonym. Weber van-Bosse (32, pp. 86, 106, 107) adopted *Cheilosporum* and listed 2 species, *Cheilosporum spectabile* (Harvey) Weber van-Bosse, and *Cheilosporum jungermannioides* (Rupr.) Areschoug, while Yendo (38, pp. 2, 17–27) adopted the genus with much wider application by proposing sections including species that are not species of *Cheilosporum* as restricted, such as those included under his sections *Alatocladia* and *Serraticardia*. He regarded *Cheilosporum elegans* Areschoug, *Cheilosporum sagittatum* (Lamx.) Aresch., *Cheilosporum jungermannioides* (Rupr.) Aresch., *Cheilosporum spectabile* (Harvey) Weber van-Bosse, and *Cheilosporum cultratum* (Harvey) Aresch. as typical species of *Cheilosporum*, listing them under the section *Eucheilosporum*. Of these species, referred to *Cheilosporum*, *Cheilosporum sagittatum* (Lamx.) Aresch. was the first mentioned by Decaisne when he proposed *Cheilosporum* as a subgenus of *Amphiroa*, and this species was not only definitely designated by Schmitz and Hauptfleisch as the type of the genus, but also cited by Yendo (38, p. 18) as one of the typical species of *Cheilosporum*. It is one of the species seemingly recognized by most authors as a typical *Cheilosporum*, so that it seems best to follow Schmitz and Hauptfleisch in considering *Cheilosporum sagittatum* (Lamx.) Aresch. as the type of the genus.

When Decaisne proposed *Cheilosporum* as a subgenus of *Amphiroa* it was limited to species primarily with conceptacles in the upper margins of the upper lobes of the intergenicula. Harvey, who reduced *Cheilosporum* to a section of *Amphiroa*, restricted it in a fashion similar to the subgeneric limitation of Decaisne. According to Areschoug, *Cheilosporum* includes species primarily with conceptacles in the upper margins of the upper lobes of the intergenicula, and with dichotomous branching. Schmitz and Hauptfleisch likewise restricted the genus to the species with the conceptacles immersed in the upper margins of the upper lobes of the intergenicula, a position of the conceptacles interpreted as terminal. The conceptacles in *Cheilosporum* as restricted are lateral, since they spring from the sides

of the segments and not from the apices of the segments. Weber van-Bosse, who adopted the genus, farther described it as consisting of species not only with conceptacles immersed in the upper margins of the upper lobes of the intergenicula, but also with genicula unizonal; with intergenicular medullary filaments straight and cells in transverse zones of equal length. Yendo extended its limit by referring to it species not only with conceptacles restricted to the upper margins of the upper lobes of the intergenicula, but also species with conceptacles scattered over the flat surfaces of the intergenicula, and with conceptacles both terminal on the apices of the ramules and lateral on the flat surfaces of the intergenicula. This author states, however, that in the true *Cheilosporum* (*Eucheilosporum*) the conceptacles are restricted to the upper margins of the upper lobes of the intergenicula. Species of *Cheilosporum* have been found not only to have conceptacles restricted to the upper margins of the upper lobes of the intergenicula, but also the genicula unizonal. They also have intergenicular medullary filaments straight, with cells in transverse zones of equal length, so that it seems proper not only to delimit *Cheilosporum* to species showing those essential characters but also to recognize its independent generic rank.

Key to the species of Cheilosporum.

a^1. Branching dichotomous.
  b^1. Margins of the intergenicula entire.
    c^1. Conceptacles single on each lobe.
      3. *C. sagittatum* (Lamx.) Aresch.
    c^2. Conceptacles 1 to 3, generally 2, on each lobe.
      4. *C. cultratum* (Harvey) Aresch.
  b^2. Margins of upper lobes variously dented.
    2. *C. multifidum* (Kuetz.) Manza.
a^2. Branching primarily dichotomous, but ultimately digitate.
  1. *C. africanum* Manza.

CHEILOSPORUM SAGITTATUM (Lamx.) Areschoug. Plate 9.

Cheilosporum sagittatum (Lamx.) ARESCHOUG in J. G. Agardh, Sp. Alg. pt. 2 2 (1852) 545.

Corallina sagittata LAMOUROUX in Freycinet, Zool. 3 (1824) 625, pl. 95, figs. 11, 12.

Amphiroa (*Cheilosporum*) *sagittatum* DECAISNE, Mem. sur les Corallines (1842) 113.

Amphiroa sagittata DECAISNE in Harvey, Ner. Austr. (1847) 102.

Fronds erect, 3 cm long; branching generally dichotomous; intergenicula near base cylindrical, about 0.5 mm long and 0.5 mm broad, on upper parts compressed, sagittate, lobe acute, about 1 mm long and 1 to 1.5 mm broad; tetrasporic conceptacles single

on upper margins of upper lobes of intergenicula. Cystocarpic and antheridial plants unknown.

Type: *Corallina sagittata* Lamouroux.

Type locality: "Île-de-France." Descriptions based on specimens in Herb. Univ. Calif.

Cheilosporum sagittatum (Lamx.) Areschoug appears not to have been studied to any considerable extent. It was first described by Lamouroux as *Corallina sagittata,* as follows: "*Corallina* dichotoma; articulis sagittatis, extremitatibus acutis vel ovariiferis." Decaisne merely listed this species as *Amphiroa* (*Cheilosporum*) *sagittata,* and Harvey referred it to *Amphiroa sagittata* under the section *Cheilosporum,* merely quoting the original description. Areschoug, on the other hand, elaborately described this species as follows:

> Fronde robusta 4 mm lata stipitata apice subdilatata, articulis mediis ramorumque subsagittatis basi attenuato-obovatis, longitudine intergenicula distantiam loborum 1, sesquilongiori, lobis patentibus subulato-acutis 1. obtusiusculis remotis keramidiis subsolitariis.

South African plants (sent by Comm. Dr. A. V. Duthie) reasonably resembling the type illustrated by Lamouroux, are about 3 cm high, with dichotomous branching, and the conceptacles borne singly on the upper margins of the upper lobes of the intergenicula.

Under *Cheilosporum* a considerable number of additional species have been proposed, of which only 5 described thus far may be satisfactorily referred to this genus. They are:

CHEILOSPORUM CULTRATUM (Harvey) Areschoug.

> *Cheilosporum cultratum* (Harvey) Areschoug in J. G. Agardh, Sp. Alg. pt. 2 2 (1852) 545, 546; Yendo, Journ. Coll. Sci. Imp. Univ. Tokyo Art. 12 20 (1905) 18.
>
> *Amphiroa cultrata* Harvey, Ner. Austr. (1847) 102, pl. 39, figs. 1–3.

Fronds 4 cm long; branching dichotomous; segments near base cylindrical, slender, proliferous, intergenicula about 0.5 mm long and 0.5 mm in diameter; on upper parts compressed, intergenicula sagittate, midrib prominent, lobes acute, about 1.5 mm long and 2 to 3 mm broad; conceptacles on upper margins of upper lobes of intergenicula 1 to 3, but generally 2 on each lobe.

Type: *Amphiroa cultrata* Harvey (may be in Herb. British Museum).

As the type was not available for study, the foregoing description is based on South African plants reasonably resembling the figures of Harvey. (10, pl. 39, figs. 1–3) This species was first re-

ferred to species of *Amphiroa*, but under the present generic restrictions it shows all the essential characters of species of *Cheilosporum* and not of species of *Amphiroa;* such as, genicula unizonal; intergenicular medullary filaments straight, cells in zones of equal length; conceptacles on upper margins of upper lobes of intergenicula.

CHEILOSPORUM AFRICANUM Manza.

Cheilosporum africanum MANZA, Proc. Nat. Acad. Sci. (11) 23 (1937) 570, 571.

Fronds 5 to 8 cm long; primary branching dichotomous, secondary lateral, divisions dichotomous or subpinnate, ultimate branchlets borne digitately; segments near base tapering downward, intergenicula cylindrical, 1 mm long and 1 to 1.5 mm broad, on upper parts compressed, on ultimate branchlets slender; intergenicula on primary branches obcordate, lobes acute; intergenicula on branchlets obcordate, lobes acuminate; 1 to 2 mm long and 1 to 3 mm broad; tetrasporic conceptacles on upper margins of upper lobes of intergenicula borne singly near axis, pores apical-marginal.

Type: tetrasporic, *Herb. Univ. Calif. No. 564605;* Still Bay, South Africa. Collected by Ecol. Surv. *S. B. 80.*

CHEILOSPORUM MULTIFIDUM (Kuetz.) Manza.

Cheilosporum multifidum (Kuetz.) MANZA, Proc. Nat. Acad. Sci. (11) 23 (1937) 571.

Amphiroa multifida KUETZING, Tab. Phyc. 8 (1858) pl. 56, fig. 1.

Fronds 3 to 5 cm long; branching largely dichotomous but sometimes with lateral proliferations; segments on lower parts slender, filiform, proliferous; segments of upper parts compressed, intergenicula obcordate or subobcordate, lobes of intergenicula of lower parts of branches obtuse, acute, or cleft, those near apices fimbriate, 1 mm long, 2 to 4 mm broad; tetrasporic conceptacles on upper margins of intergenicula, borne singly near axils, pores apical-marginal.

Type: *Amphiroa multifida* Kuetzing.

Type locality.—Cape of Good Hope.

CHEILOSPORUM ELEGANS (Hook. f. et Harvey) Areschoug.

Cheilosporum elegans (Hook. f. et Harvey) ARESCHOUG in J. G. Agardh, Sp. Alg. pt. 2 2 (1852) 546; YENDO, Journ. Coll. Sci. Imp. Univ. Tokyo Japan Art. 12 20 (1905) 18.

Amphiroa elegans HOOKER f. et HARVEY in Harvey, Ner. Austr. (1847) 101, 102.

CHEILOSPORUM JUNGERMANNIOIDES (Rupr.) Areschoug.

Cheilosporum jungermannioides (Rupr.) ARESCHOUG in J. G. Agardh, Sp. Alg. pt. 2 2 (1852) 546, 547; WEBER VAN-BOSSE, Sib. Exp. Monogr. 61 (1904) 107; YENDO, Journ. Coll. Sci. Imp. Univ. Tokyo Art. 12 20 (1905) 18.

Available specimens of *Cheilosporum elegans* and *C. jungermannioides* are fragmentary, but to all indications they are species of *Cheilosporum* as the genus is restricted and not species of *Amphiroa* to which they were referred previously. In our specimens the genicula are unizonal, the intergenicular medullary filaments straight, with cells in zones of equal length and the conceptacles on the upper margins of the upper lobes of the intergenicula, which are characters of species of *Cheilosporum* as the genus is restricted.

8. Genus LITHOTHRIX Gray

Lithothrix GRAY, Journ. Bot. 5 (1867) 33, figs. *a*, *b*.

Fronds fragile; branching pinnate, or dichotomous-pinnate; genicula unizonal; intergenicular medulla unizonal; conceptacles lateral, scattered over surfaces of intergenicula.

Type species: *Lithothrix Aspergillum* Gray.

In 1867 J. E. Gray proposed a monotypic genus, *Lithothrix*, naming the single species *Lithothrix Aspergillum* Gray. In 1904 Weber van-Bosse (32, pp. 86, 108, 109) and Yendo in 1905 (38, pp. 1, 2, 14–16) adopted the genus and recognized *Lithothrix Aspergillum* as the type species. It seems best to follow Gray, Weber van-Bosse, and Yendo in the present paper.

The genus *Lithothrix*, according to Gray, includes practically all species of the articulated corallines with pinnate branching and with conceptacles scattered over the surfaces of the intergenicula. Weber van-Bosse restricted the genus to species with "calcified constrictions replacing the nodes and the central strand of the joints consisting of long undivided noncalcified filaments standing in vertical rows and the 'conceptacula' on the joints." According to Yendo (38, pp. 1, 2) *Lithothrix* includes species with the propagating cells generated from the medulla and the genicula not well differentiated. The characterization of Weber van-Bosse, (32, p. 86) "calcified constrictions replacing the nodes," seems to mean that species of *Lithothrix* have no genicula (nodes) in the proper sense. These so-called "calcified constrictions," according to our findings, occur in similar succession as the genicula and the intergenicula of the other species of the

articulated corallines, their structure varying in the same fashion with the structure of the genicula and of the intergenicula of the other species of this group, so that in this account they will be called genicula. In the figures of the type provided by Gray, and in the type specimen (in Herb. Brit. Museum), there is no difficulty in determining a large number of plants as being *Lithothrix Aspergillum* Gray. It seems proper to delimit *Lithothrix* to species fundamentally with conceptacles lateral, scattered over the surfaces of the intergenicula; with genicula unizonal; and with the intergenicular medulla unizonal.

Species of *Lithothrix* resemble certain species of *Amphiroa* in the shape of the segments and in the position of the conceptacles. In species of *Lithothrix,* however, the segments are generally cylindrical, like in species of *Amphiroa,* and the conceptacles are lateral and borne on the surfaces of the intergenicula in similar fashion as those of certain species of *Amphiroa.* They differ from species of *Amphiroa,* however, in the modes of branching and in the microscopic structure of the genicula and of the intergenicula. In *Amphiroa* branching is strictly dichotomous, while in *Lithothrix* it is largely pinnate; in *Amphiroa* the genicula generally are multizonal, the intergenicular medulla multizonal with straight filaments, and the cells arranged in long and short transverse zones; while in *Lithothrix* the genicula and the intergenicular medullæ are unizonal, and the genicular cells are comparatively many times shorter than those of the intergenicular medullary cells.

LITHOTHRIX ASPERGILLUM (Gray) Anderson. Plate 10, figs. 1 and 2.

Lithothrix Aspergillum (Gray) ANDERSON, Zoe 2 (1891) 225.
Amphiroa nodulosa FARL., Report U. S. Fish. Comm. (1875) 715.
Amphiroa nodulosa COLL. in Hold. et Sechell, Phyc. Bor. Amer. fasc. 10 (498) (1898).
Amphiroa Aspergillum fo. *nana* SETCH. et GARD., Alg. N. W. A. (1903) 359.

Fronds erect, 8 to 13 cm long; primary branching dichotomous, ultimately lateral; intergenicula near base cylindrical, 0.5 mm long and 0.5 to 1 mm in diameter, on upper parts and on primary branches cylindrical or slightly compressed, 1 mm long and 1 to 1.5 mm broad, on ultimate branches cylindrical and very slender; genicular cells many times shorter than intergenicular medullary cells; tetrasporic conceptacles conical, scattered over surfaces of intergenicula, with pores central and tetrasporangia basal. Cystocarpic and antheridial plants unknown.

Type: *Lithothrix Aspergillum* Gray.

Type locality.—"Vancouver's Island."

Specimens of this species have been collected from the northwestern coast of North America and likewise from the coast of southern California.

Lithothrix Aspergillum, according to Gray, has conceptacles scattered over the surfaces of the intergenicula; pinnate branching; short intergenicula, compressed near the upper parts of the main branches and cylindrical on the branchlets. Weber van-Bosse merely states that the species bears the same diagnosis as the genus. Our plants showing characters that can be ascribed to the type specimen have extremely short segments; the main axis dividing dichotomously, the divisions in turn sending out slender unbranched lateral proliferations arranged in pinnate and alternate fashion. The conceptacles are conical and protrude most evidently on the surfaces of the intergenicula. In addition, the cells of the so-called genicula in this species are 4 or more times shorter than the cells of the intergenicular medulla.

9. Genus AMPHIROA Lamx. (emend. Weber van-Bosse)

Amphiroa LAMOUROUX, Nouv. Bull. des Sci. Soc. Philomat. 3 (1812) 186; Hist. Polyp. Flex. (1816) 294–302; WEBER VAN-BOSSE, Sib. Exp. Monogr. 61 (1904) 86–101.

Fronds extremely fragile; branching dichotomous, rarely irregular-dichotomous; genicula unizonal or multizonal; intergenicular medullary filaments straight, with cells always in long and short transverse zones; conceptacles lateral, scattered over surfaces of intergenicula.

Type species: *Amphiroa fragilissima* (Linn.) Lamouroux.

A considerable number of species have been referred to this genus, of which only 17 seem to have been properly established. These species have thus far been recorded from all tropical and subtropical shores.

In 1812 Lamouroux established the genus *Amphiroa* and listed under it 2 species, *Amphiroa tribulus* Lamx. and *A. cuspidata* Lamx. [synonym of *Amphiroa fragilissima* (L.) Lamx.]. In 1816 he described 13 species, including *Amphiroa rigida* Lamx., *A. tribulus*, *A. cuspidata*, and *A. fragilissima* (L.) Lamx. In 1842 Decaisne listed 23 species and practically established *Amphiroa fragilissima* (L.) Lamouroux and *A. cuspidata* Lamouroux as typical species of *Amphiroa* by including them under the section *Euamphiroa*, and by placing *Amphiroa tribulus* under

the section *Eurytion* and excluding *Amphiroa rigida* entirely from his list. In 1852 Areschoug included *Amphiroa fragilissima, A. cuspidata, A. rigida,* and *A. tribulus* among 14 others, a considerable number of which may still be referred properly to *Amphiroa* as restricted. In 1897 Schmitz and Hauptfleisch (28, pp. 542, 543) designated *Amphiroa rigida* as the type of *Amphiroa,* although it was not mentioned by Lamouroux in his original paper. Weber van-Bosse listed 17 species, including *A. fragilissima, A. tribulus,* and *A. rigida,* and referred *A. cuspidata* to *A. fragilissima;* while Yendo in 1905 likewise listed *A. fragilissima, A. tribulus,* and *A. rigida,* referring *A. cuspidata* as a form of *A. fragilissima,* and adopted these species as typical species of *Amphiroa,* since he listed them under the section *Euamphiroa,* limited to species of *Amphiroa* as the genus is restricted. Of these species, *Amphiroa fragilissima* (Linn.) Lamx. may be adopted as the type of the genus, although Schmitz and Hauptfleisch designated *A. rigida* Lamx. as the type of *Amphiroa,* not only because *Amphiroa fragilissima* (Linn.) Lamx. (syn. *A. cuspidata* Lamx.) is one of the 2 species first established by Lamouroux when he established the genus *Amphiroa,* since Lamouroux did not even mention *Amphiroa rigida* in his earlier account. In addition, this species, *Amphiroa fragilissima,* practically because the author listed it under *Euamphiroa,* but not technically because he did not definitely say so, has been adopted as the type of *Amphiroa* by Decaisne as early as 1842, listed under *Euamphiroa,* while *A. tribulus* was listed under *Eurytion,* and *Amphiroa fragilissima* is one of the species of *Amphiroa* seemingly recognized by all authors as typical *Amphiroa.* Even Yendo, who adopted a broad application of *Amphiroa,* recognized *Amphiroa fragilissima* (Linn.) Lamx. as typical *Amphiroa,* since he listed it under *Euamphiroa,* the content of which, according to our concept of the genus as limited, is still typical *Amphiroa.*

Differences of opinion have long existed with regard to the limitation of *Amphiroa.* Lamouroux states that *Amphiroa* has branching dichotomous, trichotomous, or verticillate, articuli long, separated one from the other by a naked and horny substance. According to Decaisne it includes species with conceptacles scattered over the surfaces of the intergenicula. Areschoug, who characterized *Amphiroa* in almost the same fashion as Decaisne, further limited it by elevating *Arthrocardia* and *Cheilosporum,* two subgenera of Decaisne, to independent genera.

Weber van-Bosse further limited this genus by including under it species with conceptacles scattered over the "joint," genicula unizonal or multizonal, intergenicular medullary filaments straight, and cells in long and short transverse zones. Yendo, however, extended the application of *Amphiroa* by including under it sections *Arthrocardia* and *Marginosporum*, which include species not referrable to *Amphiroa* as restricted by Weber van-Bosse. In species properly referrable to *Amphiroa* the conceptacles are always lateral and scattered over the surfaces of the intergenicula, the genicula are either unizonal or multizonal, and the intergenicular medullary filaments are straight, with cells in long and short transverse zones, so that it seems proper to delimit the genus *Amphiroa* to species showing those essential characters.

AMPHIROA FRAGILISSIMA (Linn.) Lamouroux.

Corallina fragilissima LINNÆUS, Syst. Nat. ed. 12 pt. 2 1 (1767) 1305.

Amphiroa cuspidata LAMOUROUX, Nouv. Bull. Sci. Soc. Philomat. 3 (1812) 186; Hist. Polyp. Flex. (1816) 300; DECAISNE, Mem. sur les Corallines (1842) 112; ARESCHOUG in J. G. Agardh, Sp. Alg. pt. 2 2 (1852) 531; WEBER VAN-BOSSE, Sib. Exp. Monogr. 61 (1904) 89.

Amphiroa fragilissima fo. *cuspidata* YENDO, Journ. Coll. Sci. Imp. Univ. Tokyo Art. 12 20 (1905) 3.

Fronds slender, about 4 cm long; branching strictly dichotomous, with branches arising from genicula; intergenicula cylindrical, with swollen ends in older ones, about 4 mm long and 0.5 mm in diameter, tetrasporic conceptacles semiglobular, scattered over surfaces of intergenicula, pores central and tetrasporangia basal. Cystocarpic and antheridial plants unknown.

Type: *Corallina fragilissima* Linnæus.

Type locality.—"O. Americano."

Amphiroa fragilissima was first described as *Corallina fragilissima* Linnæus, primarily recognizable by its filiform articuli and dichotomous branching. According to Lamouroux, *Amphiroa fragilissima* has branching dichotomous, branches capillary, and articuli cylindrical and with swollen extremities. Areschoug described *Amphiroa fragilissima* (Linn.) Lamx. as follows:

Fronde pulvinato-caespitosa ultra-setacea subirregulariter dichotoma, articulis cylindraceis utraque extremitate nodoso-tumescentibus diametro 6 plo–10 plo longioribus, ultimis apice obtusiusculis, geniculis lineaeformibus.

Weber van-Bosse, on examination of the type of *Amphiroa fragilissima* of Lamouroux, gives the following description:

Fronds articulated, cylindrical, branched at the node di- or trichotomously, often with adventitious branches. Joints long, many times longer than broad, in older specimens swollen at top and base in the form of a ball or pad by local divisions in longitudinal and vertical direction of the cells of the cortical layer. Nodes swollen, cushionlike in conformity with the swollen tops and bases of the joints. Central strand built up of 4 to 8 rows of long cells, seldom 2 or 3 rows of long cells, mostly 4 rows, followed by one row or two rows of short cells.

Our specimens reasonably resemble the Linnæan type, of which we have excellent photographs. The fronds are slender, with branching strictly dichotomous, branches arising from the genicula, with each geniculum bearing branches, with all the ends of the intergenicula on the older portions swollen, and with conceptacles scattered over the surfaces of the intergenicula.

Species of *Amphiroa* have been studied very thoroughly by Weber van-Bosse. (32, pp. 86–101) Of a considerable number of species included under *Amphiroa*, there seem to be only 16 additional fairly well established species.

AMPHIROA TRIBULUS Lamouroux.

Amphiroa tribulus LAMOUROUX, Nouv. Bull. des Sci. Soc. Philomat. 3 (1812) 86; Hist. Polyp. Flex. (1816) 301, 302; DECAISNE, Mem. sur les Corallines (1842) 113; ARESCHOUG in J. G. Agardh, Sp. Alg. pt. 2 2 (1852) 534; YENDO, Journ. Coll. Sci. Imp. Univ. Tokyo Art. 12 20 (1905) 3; WEBER VAN-BOSSE, Sib. Exp. Monogr. 61 (1904) 99.

AMPHIROA CRASSA Lamouroux.

Amphiroa crassa LAMOUROUX in Decaisne, Mem. sur les Corallines (1842) 112; HARVEY, Ner. Austr. (1847) 97; WEBER VAN-BOSSE, Sib. Exp. Monogr. 61 (1904) 99; YENDO, Journ. Coll. Imp. Univ. Tokyo Art. 12 20 (1905) 5.

AMPHIROA CANALICULATA von Mart.

Amphiroa canaliculata VON MART. in Weber van-Bosse, Sib. Exp. Monogr. 61 (1904) 99; YENDO, Journ. Coll. Imp. Univ. Tokyo Art. 12 20 (1905) 5.

AMPHIROA INVOLUTA Kuetzing.

Amphiroa involuta KUETZING, Tab. Phyc. 8 (1858) 23, pl. 48, fig. 2, *e–g;* WEBER VAN-BOSSE, Sib. Exp. Monogr. 61 (1904) 99; YENDO, Journ. Coll. Imp. Univ. Tokyo Art. 12 20 (1905) 3.

AMPHIROA ANCEPS (Lamk.) Decaisne. Plate 11, figs. 1 and 2.

Amphiroa anceps (Lamk.) DECAISNE, Mem. sur les Corallines (1842) 113; HARVEY, Ner. Austr. (1847) 98; ARESCHOUG in J. G. Agardh, Sp. Alg. pt. 2 2 (1852) 536, 537; KUETZING, Tab. Phyc. 8 (1858) 24, pl. 49, fig. 4, *f–h;* WEBER VAN-BOSSE, Sib. Exp. Monogr. 61 (1904) 99; YENDO, Journ. Coll. Imp. Univ. Tokyo Art. 12 20 (1905) 4.

AMPHIROA BOWERBANKII Harvey.

Amphiroa Bowerbankii HARVEY, Ner. Austr. (1847) 97, pl. 37, figs. 1–6; WEBER VAN-BOSSE, Sib. Exp. Monogr. 61 (1904) 99; YENDO, Coll. Imp. Univ. Tokyo Art. 12 20 (1905) 5.

AMPHIROA BEAUVOISII Lamouroux.

Amphiroa Beauvoisii LAMOUROUX, Hist. Polyp. Flex. (1816) 299; KUETZING, Tab. Phyc. 8 (1858) 21, pl. 44, fig. 1, *a–d;* WEBER VAN-BOSSE, Sib. Exp. Monogr. 61 (1904) 99; YENDO, Coll. Imp. Univ. Tokyo Art. 12 20 (1905) 4.

AMPHIROA EPHEDRAEA (Lamk.) Decaisne.

Amphiroa ephedraea (Lamk.) DECAISNE, Mem. sur les Corallines (1842) 112; HARVEY, Ner. Austr. (1847) 95, pl. 39, figs. 1–4; ARESCHOUG in Agardh, Sp. Alg. pt. 2 2 (1852) 534; WEBER VAN-BOSSE, Sib. Exp. Monogr. 61 (1904) 99; YENDO, Coll. Imp. Univ. Tokyo Art. 12 20 (1905) 4.

AMPHIROA LINEARIS Kuetzing.

Amphiroa linearis KUETZING, Tab. Phyc. 8 (1858) 22, pl. 46, fig. 2, *a–c;* WEBER VAN-BOSSE, Sib. Exp. Monogr. 61 (1904) 99.

AMPHIROA ANASTOMOSANS Weber van-Bosse.

Amphiroa anastomosans WEBER VAN-BOSSE, Sib. Exp. Monogr. 61 (1904) 100.

AMPHIROA FOLICEA Lamouroux.

Amphiroa foliacea LAMOUROUX in Freycinet, Voyage Autour du Monde Zoöl. 3 (1824) 628, pl. 93, figs. 2, 3; WEBER VAN-BOSSE. Sib. Exp. Monogr. 61 (1904) 100; YENDO, Coll. Imp. Univ. Tokyo Art. 12 20 (1905) 5.

AMPHIROA VALONIOIDES Yendo.

Amphiroa valonioides YENDO, Corallinae verae Japonicae. Journ. Coll. Sci. Imp. Univ. Tokyo Art. 3 16 (1902) 5, pl. 1, figs. 1–3; pl. 4, fig. 1; WEBER VAN-BOSSE, Sib. Exp. Monogr. 61 (1904) 100; YENDO, A Revised List of Corallinae. Journ. Coll. Sci. Imp. Univ. Tokyo Art. 12 20 (1905) 2.

AMPHIROA VERRUCOSA Lamouroux.

Amphiroa verrucosa LAMOUROUX, Hist. Polyp. Flex. (1816) 300; DECAISNE, Mem. sur les Corallines (1842) 112; KUETZING, Tab. Phyc. 8 (1858) 20, pl. 42, fig. 3; WEBER VAN-BOSSE, Sib. Exp. Monogr. 61 (1904) 100.

AMPHIROA RIGIDA Lamouroux.

Amphiroa rigida LAMOUROUX, Hist. Polyp. Flex. (1816) 297; ARESCHOUG in J. G. Agardh, Sp. Alg. pt. 2 2 (1852) 532; WEBER VAN-BOSSE, Sib. Exp. Monogr. 61 (1904) 100; YENDO, Coll. Sci. Imp. Univ. Tokyo Art. 12 20 (1905) 3.

AMPHIROA NODULOSA Kuetzing.

Amphiroa nodulosa KUETZING, Tab. Phyc. 8 (1858) 19, pl. 41, fig. 1; WEBER VAN BOSSE, Sib. Exp. Monogr. 61 (1904) 100; YENDO, Coll. Sci. Imp. Univ. Tokyo Art. 12 20 (1905) 4.

AMPHIROA DUBIA Kuetzing.

Amphiroa dubia KUETZING, Tab. Phyc 8 (1858) 24, pl. 49, fig. 1, *a–c;* WEBER VAN-BOSSE, Sib. Exp. Monogr. 61 (1904) 100.

Specimens referred to the foregoing species on examination all showed essential specific characters of *Amphiroa;* such as genicula multizonal, intergenicular medullary filaments straight with zones of long and short cells, and conceptacles lateral on the surfaces of the intergenicula. These species are, likewise, recognized by a considerable number of authors as species of *Amphiroa,* among them Weber van-Bosse,(32) who restricted the genus in a fashion similar to the restriction of the genus in the present paper. Accurate descriptions of these species could not be prepared at this time as available specimens are merely fragments of segments. Consequently they are merely listed under *Amphiroa.*

10. Genus BOSSEA Manza

Bossea MANZA, Proc. Nat. Acad. Sci. U. S. A. (2) 23 (1937) 46.

Fronds fragile; branching dichotomous, pinnate or pinnate-dichotomous; segments near base cylindrical or compressed, on upper parts compressed; genicula unizonal; intergenicular medullary filaments straight, with cells in transverse zones of equal length; conceptacles semiglobular or conical, scattered over surfaces of intergenicula.

Type species: *Bossea plumosa* Manza.

According to all indications species of this genus occur only on temperate and subtropical shores. A large number of specimens of a number of properly identified and described species of this genus have been collected from the coast of California by Profs. W. A. Setchell and N. L. Gardner and by myself. Decaisne(6, p. 112) reported 2 species, *Amphiroa* (*Arthrocardia*) *Orbigniana,* attributed to San Carlos, coast of Chile, and *Amphiroa* (*Arthrocardia*) *californica,* attributed to the coast of California (Monterey).

Seven additional species of *Bossea* are known with reasonable certainty, some of them previously described as species of *Amphiroa* or of *Cheilosporum*. In the position of the conceptacles, species of *Bossea* are similar to species of *Amphiroa*, all conceptacles in both groups being restricted to the flat surfaces of the intergenicula. Species of these 2 genera differ, however, in the microscopic structure of the genicula and of the intergenicula: in *Amphiroa* the genicula are mostly multizonal, and the intergenicular medullary filaments straight, with cells in long and short transverse zones; in *Bossea* all genicula are unizonal and the intergenicular medullary filaments are likewise straight, but the cells are in transverse zones of equal length. In addition, practically all species of *Amphiroa* have dichotomous branching, while in *Bossea* most species have pinnate branching. In the structure of the genicula and of the intergenicula, species of *Bossea* and of *Cheilosporum* are similar, both having unizonal genicula, and intergenicular medullary filaments are straight, with cells in transverse zones of equal length. The 2 genera differ primarily in the position of the conceptacles. In *Bossea* the conceptacles are on the flat surfaces of the intergenicula, and in *Cheilosporum*, according to our restriction of this genus, they are on the upper margins of the upper lobes of the intergenicula.

Key to the species of Bossea.

a^1. Branching pinnate.
  b^1. Branches almost of same height..... 1. *B. corymbifera* Manza.
  b^2. Branches not of same height.
    c^1. Young branches or branchlets ovate..... 2. *B. frondifera* Manza.
    c^2. Young branches or branchlets elongated.
      d^1. Branches arising in zones which are separated by zones without branches ..... 3. *B. interrupta* Manza.
      d^2. Branches arising from almost all intergenicula. 4. *B. plumosa* Manza.

a^2. Branching wholly or partially dichotomous.
  b^1. Branching dichotomous.
    c^1. Intergenicula with upper lobes mostly acute. 5. *B. Orbigniana* (Decne.) Manza.
    c^2. Intergenicula with upper lobes mostly obtuse. 6. *B. Gardneri* Manza.
  b^2. Branching partly dichotomous.
    c^1. Primary branching dichotomous, ultimately digitate. 7. *B. californica* (Decne.) Manza.
    c^2. Primary branching pinnate, ultimately dichotomous. 8. *B. dichotoma* Manza.

BOSSEA PLUMOSA Manza. Plate 12, figs. 1 and 2.

Bossea plumosa MANZA, Proc. Nat. Acad. Sci. U. S. A. (2) 23 (1937) 46.

Fronds erect, 3 to 6 cm long; branching plumosely bi- or tripinnate and opposite, branches on lower parts short ramules, on upper parts long branches once or twice pinnately divided with divisions short on lower parts, long on upper parts; intergenicula near base slightly compressed, 1 mm long and 1 mm broad, on upper parts on primary branches comparatively thick, compressed-cuneate, 1 mm long and 2 mm broad, on branchlets thin, compressed-cuneate or obcordate with obtuse lobes 1 mm long and 2 mm broad, on ramules spathulate, 1 to 2 mm long and 0.5 to 1 mm broad; conceptacles conical on flat surfaces of intergenicula, 2 to 4, mostly 2 on each flat surface, borne singly or in pairs on each wing and arranged in vertical rows along axis, single and central on flat surfaces of ramules, with pores central and tetrasporangia basal. Cystocarpic and antheridial plants unknown.

Type: *Bossea plumosa* Manza, tetrasporic, Moss Beach, coast of Central California, west coast of North America (*Herb. Univ. Calif. No. 545710*).

Bossea plumosa is the most characteristic species of the genus. The fronds appear like feathers, having decidedly and comparatively thick axes with slender and flexible lateral divisions. The basal segments are cylindrical or slightly compressed, with the segments above thicker and more compressed. The lateral divisions consist of ramules and long branches, the simple ramules are always situated near the base of the primary axes of the fronds and near the bases of the branches or branchlets, while the long compound branches or branchlets in each case occur above them.

Seven additional species described thus far may be referrable to this genus. They are:

BOSSEA ORBIGNIANA (Decne.) Manza.

Bossea Orbigniana (Decne.) MANZA, Proc. Nat. Acad. Sci. U. S. A. 23 (1937) 563, 564.

Amphiroa (*Arthrocardia*) *Orbigniana* DECAISNE, Mem. sur les Corallines (1842) 112.

Amphiroa Orbigniana DECAISNE in Harvey, Ner. Austr. (1847) 100; ARESCHOUG in J. G. Agardh, Sp. Alg. pt. 2 2 (1852) 539.

Cheilosporum Orbignianum (Decne.) YENDO, A Revised List of Corallinae. Journ. Coll. Sci. Imp. Univ. Tokyo, Art. 12 20 (1905) 20.

Fronds 7 to 21 cm long; branching wholly or partially dichotomous; intergenicula near base cylindrical, 1 to 2 mm long and 2 mm broad, intergenicula on upper parts compressed-cuneate with lobes acute, or obcordate with lobes obtuse, 2 mm long, 2 to

3 mm broad; tetrasporic conceptacles conical, on flat surfaces of intergenicula, 2 on each surface borne singly on each wing near upper margin of lobe, very close to midrib, pores central, tetraspores basal.

Type: *Amphiroa* (*Arthrocardia*) *Orbigniana* Decaisne.

Type locality.—"Patagonia S. Carlos Chiloensisque littora."

The type specimen is not available for examination, but in our collection of the articulated corallines we have plants referred to this species and showing characters consistent with the type.

BOSSEA CALIFORNICA (Decne.) Manza.

Bossea californica (Decne.) MANZA, Proc. Nat. Acad. Sci. U. S. A. 23 (1937) 561, 562.

Amphiroa (*Arthrocardia*) *californica* DECAISNE, Mem. sur les Corallines (1842) 112.

Cheilosporum californicum YENDO, a revised list of Corallinae. Journ. Coll. Sci. Imp. Univ. Tokyo 20 (1905) 19.

Fronds 5 to 12 cm long; branching dichotomous-digitate-cymoid; intergenicula near base thick, cylindrical, 1 to 3 mm long, 2 mm broad, intergenicula of upper parts thick, compressed, mostly obcordate, with lobes rounded, 2 to 5 mm long and 2 to 6 mm broad; tetrasporic conceptacles on flat surfaces of intergenicula, 2 to 8, mostly 6, on each surface, arranged in rows along lateral margins, 2 to 4 on each side, pores central.

Type: *Amphiroa* (*Arthrocardia*) *californica* Decne. Topotype: tetrasporic, *Herb. Univ. Calif. No. 266290.*

Type locality.—"California (Monterey)."

The type of this species not being available for study, specific descriptions have been based on topotypes. According to the present generic limitations, this species bears essential characters of *Bossea* and not of any one of the other genera to which it has hitherto been referred.

BOSSEA CORYMBIFERA Manza. Plate 13.

Bossea corymbifera MANZA, Proc. Nat. Acad. Sci. U. S. A. 23 (1937) 562.

Fronds 3 to 5 cm long; branching bi-, tri-, or pentacotomose-corymboid; intergenicula near base thick, cylindrical, 1 to 2 mm long, 1 mm broad, on upper parts compressed, thick, cuneate or obcordate, with lobes obtuse, 1 to 2 mm long and 2 to 3 mm broad; conceptacles semiglobular on flat surfaces of intergenicula, 2 to 4 on each surface, 1 or 2 on each wing arranged in vertical rows along axis, with pores central and tetraspores basal.

Type: tetrasporic, *Herb. Univ. Calif. No. 545752;* Point Lobos, Carmel Bay, coast of central California, west coast of North America. Collected by A. V. Manza.

BOSSEA FRONDIFERA Manza. Plate 14.

Bossea frondifera MANZA, Proc. Nat. Acad. Sci. 23 (1937) 562, 563.

Fronds 2 to 7 cm long; branching plumosely pinnate and opposite or pinnately decompound, young branches ovate; intergenicula near base cylindrical, 1 mm long, 1 mm broad, on upper parts cuneate or obcordate, 1 to 2 mm long, 1 to 3 mm broad with lobes obtuse; tetrasporic conceptacles conical, 2 on each surface of intergeniculum, borne singly near upper lobes, pore central, tetraspores basal.

Type: tetrasporic, *Herb. Univ. Calif. No. 545757;* Moss Beach, San Mateo County, coast of central California, west coast of North America. Collected by A. V. Manza.

BOSSEA GARDNERI Manza. Plate 15.

Bossea Gardneri MANZA, Proc. Nat. Acad. Sci. U. S. A. 23 (1937) 563.

Fronds 5 to 18 cm long; branching dichotomous, or primary branching lateral but ultimately dichotomous; intergenicula near base slender, cylindrical or slightly compressed, 1 mm long, 1 mm broad, on upper parts on primary branches cuneate, 1 to 2 mm long, 1 to 3 mm broad, with lobes obtuse, on branchlets obcordate with thin wings and prominent midrib, 2 to 3 mm long, 2 to 4 mm broad; tetrasporic conceptacles semiglobular, 2 to 6 (mostly 4) on flat surfaces, 1 to 3 on each wing arranged in rows along midrib, pores central, tetraspores basal.

Type: tetrasporic, *Herb. Univ. Calif. No. 545763;* Pacific Grove, Monterey County, coast of central California, west coast of North America. Collected by N. L. Gardner.

BOSSEA INTERRUPTA Manza. Plate 16.

Bossea interrupta MANZA, Proc. Nat. Acad. Sci. U. S. A. 23 (1937) 563.

Fronds 5 to 13 cm long; branching bi- or tripinnate and opposite, branches arising in groups separated from one another by segments bearing simple branchlets; intergenicula near base thick, cylindrical, 1 to 2 mm long, 2 mm in diameter, on upper parts on primary branches compressed-obcordate, with thin wings and lobes obtuse, 2 mm long, 2 to 4 mm broad, on branchlets spathulate, 3 mm long, 1 to 2 mm broad; tetrasporic concep-

tacles semiglobular, on flat surfaces of intergenicula, 2 on each flat surface borne singly on each wing near upper margins of lobes, very close to midrib, and on ramules borne singly on central part, pores central, tetraspores basal.

Type: tetrasporic, *Herb. Univ. Calif. No. 545969;* Pacific Grove, Monterey County, coast of central California, west coast of North America. Collected by A. V. Manza.

BOSSEA DICHOTOMA Manza. Plate 17.

Bossea dichotoma MANZA, Proc. Nat. Acad. Sci. U. S. A. 23 (1937) 562.

Fronds 6 to 12 cm long; primary branching pinnate to subalternate, ultimately dichotomous; intergenicula near base slender, compressed, 1 to 2 mm long, 1.5 mm broad, on upper parts compressed-cuneate to subcordate, 2 to 3 mm long, 2 to 6 mm broad, with lobes rounded; tetrasporic conceptacles semiglobular, on flat surfaces of intergenicula, 2 to 4 (usually 2) on each flat surface, borne singly or in pairs arranged in vertical rows along axis, pores central, tetraspores basal.

Type specimen: tetrasporic, *Herb. Univ. Calif. No. 545756;* Moss Beach, San Mateo County, coast of central California, west coast of North America. Collected by A. V. Manza.

11. Genus PACHYARTHRON Manza

Pachyarthron MANZA, Proc. Nat. Acad. Sci. U. S. A. (2) 23 (1937) 45.

Fronds fragile; branching dichotomous or irregular-dichotomous; segments cylindrical or slightly compressed; genicula unizonal; intergenicular medullary filaments straight, with cells in transverse zones of equal length; conceptacles semiglobular, scattered over surfaces of intergenicula.

Type species: *Pachyarthron cretaceum* (P. et R.) Manza.

At present *Pachyarthron* appears to be a monotypic genus, the only species known being *Pachyarthron cretaceum*, which is recorded only from cold parts of north Pacific coasts. It has been collected from Unalaschka (the type locality), Saint Lawrence Island, and Japan (Rikuzen, Hakkodate, and Otaru Provinces; Rishira Island). This genus is more closely related to *Amphiroa* than to *Corallina* or *Arthrocardia*, to which the species has been previously referred. In habit it shows all characters ascribed to species of *Amphiroa*, having wholly or partially dichotomous branching and the position of the conceptacles scattered over the surfaces of the intergenicula. *Amphiroa* and

Pachyarthron differ merely in microscopic structure of the genicula and of the intergenicula.(22, p. 45) The type specimen made available through the courtesy of Dr. Anna Weber van-Bosse shows characters different from any one of the genera to which the species has previously been referred. Species of *Pachyarthron* differ from species of *Amphiroa* in that the genicula are unizonal and the intergenicular medullary filaments straight with cells in zones of equal length; while in species of *Amphiroa* the genicula are mostly multizonal and intergenicular, and the medullary filaments are straight, with transverse zones of long and short cells. Species of *Pachyarthron* differ from species of *Corallina* and *Arthrocardia* primarily in the positions of the conceptacles, which in *Pachyarthron* are scattered over the surfaces of the intergenicula, and in *Corallina* and *Arthrocardia*, terminal.(22)

PACHYARTHRON CRETACEUM (P. et R.) Manza. Plate 18.

Pachyarthron cretaceum (P. et R.) MANZA, Proc. Nat. Acad. Sci. U. S. A. (2) 23 (1937) 45.

Corallina cretacea P. ET R., Ill. 40 (1840) 20, fig. 104.

Amphiroa cretacea (P. et R.) ARESCHOUG in J. G. Agardh, Sp. Alg. pt. 2 2 (1852) 533.

Amphiroa cretacea ENDL. in Kuetzing, Tab. Phyc. 8 (1858) 22, pl. 45, figs. *a–f;* YENDO, Corallinae Japonicae. Journ. Coll. Sci. Imp. Univ. Tokyo pt. 3 16 (1902) 7, pl. 1, fig. 4; pl. 4, fig. 2; A revised list of Corallinae. Journ. Coll. Sci. Imp. Univ. Tokyo Art. 12 20 (1905) 10.

Arthrocardia cretacea (P. et R.) WEBER VAN-BOSSE, Sib. Exp. Monogr. 61 (1904) 105, pl. 15, fig. 8.

Fronds erect, 5 to 6 cm long; branching dichotomous or irregular-dichotomous; intergenicula near base cylindrical, 2 to 3 mm long and 1 to 2 mm in diameter, on upper parts on primary branches cylindrical or slightly compressed, on ultimate branchlets cylindrical, with apices slightly tapering, 2 to 4 mm long and 1 to 3 mm in diameter; tetrasporic conceptacles semiglobular, scattered over surfaces of intergenicula, pores central, tetraspores basal. Cystocarpic and antheridial plants unknown.

Type: *Corallina cretacea* P. et R.

A large number of plants collected from Unalaschka by Prof. W. A. Setchell, from Saint Lawrence Island, by Otto Geist in 1931, and from Japan (Rikuzen, Hakkodate, and Otaru Provinces; Rishira Island) by Yendo, agree in all essential characters with the type fragments. Only the plants collected from Saint Lawrence Island are whole plants, all the rest being fragments,

and our specific diagnosis is based upon them. Practically all the segments are cylindrical, except those on the central parts where they are sometimes slightly compressed; the basal segments slightly tapering downwards; and the ultimate branches slightly tapering upwards. It appears that the normal branching is dichotomous and the lateral branches normally occurring are merely nontypical proliferations.

12. Genus METAGONIOLITHON Weber van-Bosse

Metagoniolithon WEBER VAN-BOSSE, Sib. Exp. Monogr. 61 (1904) 86, 101–104.

Fronds fragile; branching verticillate, dichotomous or verticillate-dichotomous, with branches arising from cortex of genicula, and with apices covered with a mucilaginous cap; genicula multizonal; intergenicular medullary filaments straight, with cells in transverse zones of equal length; conceptacles lateral, scattered over surfaces of intergenicula or restricted on lower side of branches.

Type species: *Metagoniolithon charoides* (Lamx.) Weber van-Bosse.

Four species have been described as belonging to *Metagoniolithon*. Specimens have been recorded from the coast of Australia only, and it appears that the species of *Metagoniolithon* are strictly Australian, with their distribution subtropical.

Weber van-Bosse proposed the genus *Metagoniolithon* and referred to it 3 species, *M. charoides*, *M. graniferum*, and *M. stelligerum*. In 1905 Yendo(38, pp. 1, 12, 14) adopted the genus but recognized only 2 species of Weber van-Bosse, *M. charoides* and *M. stelligerum*, in addition to his *M. gracile* and listed *M. graniferum* as species inquirenda. Weber van-Bosse first mentioned *M. charoides*, which was likewise mentioned first by Yendo, so that it seems to have been recognized by these authors as the type of the genus.

The genus *Metagoniolithon* as defined by Weber van-Bosse includes species with

> Joints cylindrical; in the central strand, the cells have throughout the whole joint almost the same dimension and stand vertically one above the other; nodes consist of many rows of cells which are much smaller and have thicker walls than the cells in the joint; conceptacula on the joints.

According to Yendo the genus comprises species with mother cells of the propagating cells generated in the medulla; genicula multizonal; ramuli starting from genicula; articuli cylindrical;

and branching verticillate. Fragments of the type specimen and a large number of species in our collections that are properly referable to *Metagoniolithon*, made available through the courtesy of the different European herbaria [from the Herbarium of the Museum of Paris, *Amphiroa ephedraea, Corallina stelligera, A. jubata* Lamx.; from the Herbarium of the British Museum, *A. stelligera, A. charoides, A. granifera* Harvey, *A. intermedia* Harvey; *A. granifera* Harvey, *A. charoides* Lamx. (type), *A. stelligera*, and *A. intermedia* (Lamx.)] have the conceptacles strictly scattered over the surfaces of the intergenicula or on the lower sides of the branches; branching either wholly or partially verticillate, with branches arising from the genicula and apices covered with a mucilaginous cap; genicula multizonal, intergenicular medullary filaments straight, with cells in transverse zones of equal length, so that it seems proper to restrict the genus to species showing those essential characters. The apical envelope of the branches the exact significance of which is not yet understood, appears as a continuous mucilaginous membrane similar to the more complex root cap in the flowering plants.

METAGONIOLITHON CHAROIDES (Lamx.) Weber van-Bosse. Plate 19.

Metagoniolithon charoides (Lamx.) Weber van-Bosse.

Amphiroa charoides Lamouroux, Hist. Polyp. Flex. (1816) 301; Decaisne, Mem. sur les Corallines (1842) 112; Harvey, Ner. Austr. (1847) 96; Areschoug in J. G. Agardh, Sp. Alg. pt. 2 2 (1852) 539, 540; Kuetzing, Tab. Phyc. 8 (1858) 25, pl. 52, fig. 1, *a–e*.

Fronds erect, 6 cm long; branching verticillate, with branches of simple ramules and long branches once or twice divided with ultimate divisions of simple ramules, arising from genicula, with every geniculum giving rise to branches; intergenicula cylindrical, 1 to 1.5 cm long and 1 to 2 mm in diameter; tetrasporic conceptacles conical, in single horizontal rows on lower sides of ramules. Cystocarpic and antheridial plants unknown.

Type locality.—"Australasie."

Metagoniolithon charoides was first described by Lamouroux as *Amphiroa charoides*, with verticillate branching and tuberculose articuli. Areschoug states:

> Fronde breviori tereti, primaria di- trichotoma, ramulis verticillatis, articulis cylindraceis, utraque extremitate nodoso-incrassatis, inferioribus brevioribus, superioribus diametro usque 8 plo longioribus, geniculis diametro vix longioribus, keramidiis ad ramules subsecundia.

According to Weber van-Bosse, it has a slightly flattened "joint," 1 to 3 cm long and up to 2 mm broad; rather short "nodes."

entirely surrounded by pseudowhorls of branches; conceptacles appearing on underside of branches. *Metagoniolithon charoides* (Lamx.) Weber van-Bosse is the largest species thus far known in this genus. The branching is strictly verticillate with the ultimate divisions of simple ramules. In this species, likewise, every geniculum gives rise to branches, and the conceptacles seem restricted on the underside of the ramules.

The following three additional species seem to be properly established:

METAGONIOLITHON GRANIFERUM (Harvey) Weber van-Bosse.

Metagoniolithon graniferum (Harvey) WEBER VAN-BOSSE, Sib. Exp. Monogr. 61 (1904) 103.

Amphiroa granifera HARVEY, Phyc. Austr. 4 (1862) pl. 230.

METAGONIOLITHON STELLIGERA (Lamk.) Weber van-Bosse. Plate 20.

Metagoniolithon stelligera (Lamk.) WEBER VAN-BOSSE, Sib. Exp. Monogr. 61 (1904) 103; YENDO, A Revised List of Carollinae. Journ. Coll. Sci. Imp. Univ. Tokyo Art. 12 20 (1905) 12.

Corallina stelligera LAMARCK, Mem. du Mus. 2 (1815) 239.

Amphiroa stelligera (Lamk.) ARESCHOUG in J. G. Agardh, Sp. Alg. pt. 2 2 (1852) 540.

METAGONIOLITHON GRACILE (Harvey) Yendo.

Metagoniolithon gracile (Harvey) YENDO, Journ. Coll. Sci. Imp. Univ. Tokyo Art. 12 20 (1905) 12.

Amphiroa gracile HARVEY, Phyc. Austr. 4 (1862) pl. 231.

Metagoniolithon graniferum, M. stelligera, and *M. gracile* show characters of species of *Metagoniolithon* as restricted; such as conceptacles lateral on surfaces of intergenicula; genicula multizonal; intergenicular medullary filaments straight, with cells in zones of equal length. They do not show characters of species of *Amphiroa,* under which they were generally referred previously. In addition, they are listed as species of *Metagoniolithon* by Weber van-Bosse(32) who founded the genus. Unfortunately, however, available specimens referred to those species are merely fragments of the segments, and therefore unsuitable for specific diagnosis.

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ILLUSTRATIONS

PLATE 1. JOCULATOR PINNATIFOLIUS MANZA

FIG. 1. Habit of tetrasporic articulated plant, × 1.6; *2*, enlarged portions of tetrasporic frond, showing position of conceptacles, × 33.

PLATE 2. CALLIARTHRON CHEILOSPORIOIDES MANZA

FIG. 1. Habit of tetrasporic articulated plant, × 0.5; *2*, antheridial articulated plant, × 0.5; *3*, enlarged portion of articulated frond, showing position of conceptacles, × 5.5.

PLATE 3. CALLIARTHRON PINNULATUM MANZA

Habit of tetrasporic articulated plant, × 1.

PLATE 4. CALLIARTHRON REGENERANS MANZA

FIG. 1. Habit of tetrasporic articulated plant, × 0.3; *2*, habit of antheridial articulated plant, × 0.3; *3*, habit of cystocarpic articulated plant, × 0.5; *4*, longitudinal section of intergenicular medulla, × 118.

PLATE 5. CALLIARTHRON SCHMITTII MANZA

Habit of tetrasporic articulated plant, × 3.

PLATE 6. CALLIARTHRON SETCHELLIAE MANZA

FIG. 1. Habit of tetrasporic articulated plant, × 0.5; *2*, habit of antheridial articulated plant, × 0.5; *3*, habit of cystocarpic articulated plant, × 0.5; *4*, longitudinal section of cystocarpic conceptacle, × 62.5.

PLATE 7. CORALLINA (EUCORALLINA) OFFICINALIS LINNÆUS

FIG. 1. Longitudinal section of geniculum, × 93.5; *2*, longitudinal section of geniculum and intergeniculum, × 39.5; *3*, longitudinal section of intergeniculum, × 134; *4*, longitudinal section of tetrasporic conceptacle, × 101.5; *5*, longitudinal section of antheridial conceptacle, × 101.5.

PLATE 8. DUTHIEA SETCHELLII MANZA

FIG. 1. Habit of tetrasporic articulated plant, × 1.8; *2*, enlarged portion of articulated frond, showing conceptacle, × 82.8.

PLATE 9. CHEILOSPORUM SAGITTATUM (LAMX.) ARESCHOUG

Habit of tetrasporic articulated fronds, × 3.

PLATE 10. LITHOTHRIX ASPERGILLUM GRAY

FIG. 1. Habit of tetrasporic articulated plant, × 0.7; *2*, longitudinal section of segments, × 92.5.

PLATE 11. AMPHIROA ANCEPS (LAMK.) DECNE.

FIG. 1. Longitudinal section of geniculum, × 129.6; *2*, longitudinal section of geniculum and intergeniculum, × 129.6.

PLATE 12. BOSSEA PLUMOSA MANZA

FIG. 1. Habit of tetrasporic articulated plant, × 1.4; *2*, enlarged portion of articulated plant, showing position of conceptacles, × 26.6.

PLATE 13. BOSSEA CORYMBIFERA MANZA

Habit of tetrasporic articulated plants, × 1.

PLATE 14. BOSSEA FRONDIFERA MANZA

Habit of tetrasporic articulated plants, × 1.

PLATE 15. BOSSEA GARDNERI MANZA

Habit of tetrasporic articulated plant, × 0.7.

PLATE 16. BOSSEA INTERRUPTA MANZA

Habit of tetrasporic articulated plants, × 1.

PLATE 17. BOSSEA DICHOTOMA MANZA

Habit of tetrasporic articulated plant, × 1.

PLATE 18. PACHYARTHRON CRETACEUM MANZA

Habit of tetrasporic articulated plant, × 2.5.

PLATE 19. METAGONIOLITHON CHAROIDES WEBER VAN-BOSSE

Habit of tetrasporic plant, × 4.

PLATE 20. METAGONIOLITHON STELLIGERA WEBER VAN-BOSSE

FIG. 1. Longitudinal section of geniculum, × 150; *2*, longitudinal section of intergeniculum, × 79; *3*, enlarged portion of articulated frond showing mode of branching and caplike envelope at ends of branches, × 59.3.

PLATE 1. JOCULATOR PINNATIFOLIUS MANZA.

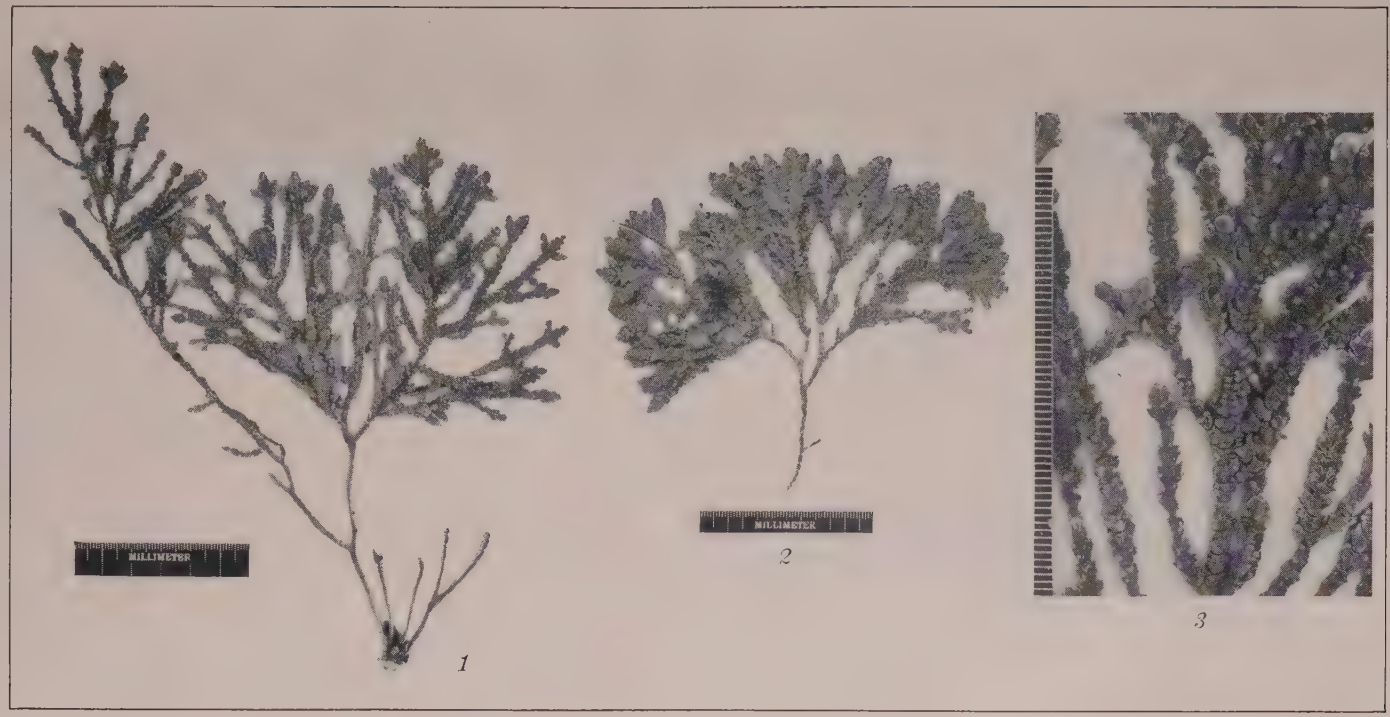

PLATE 2. CALLIARTHRON CHEILOSPORIOIDES MANZA.

PLATE 3. CALLIARTHRON PINNULATUM MANZA.

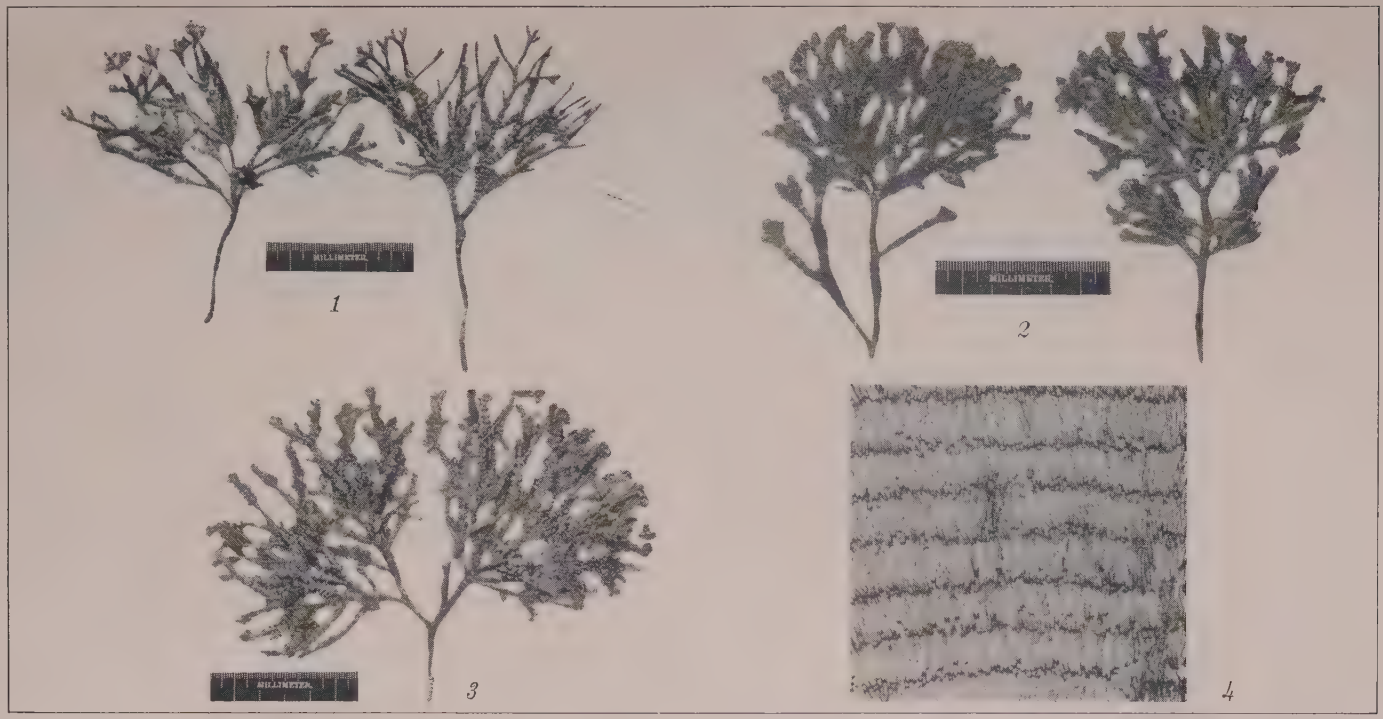

PLATE 4. CALLIARTHRON REGENERANS MANZA.

PLATE 5. CALLIARTHRON SCHMITTII MANZA.

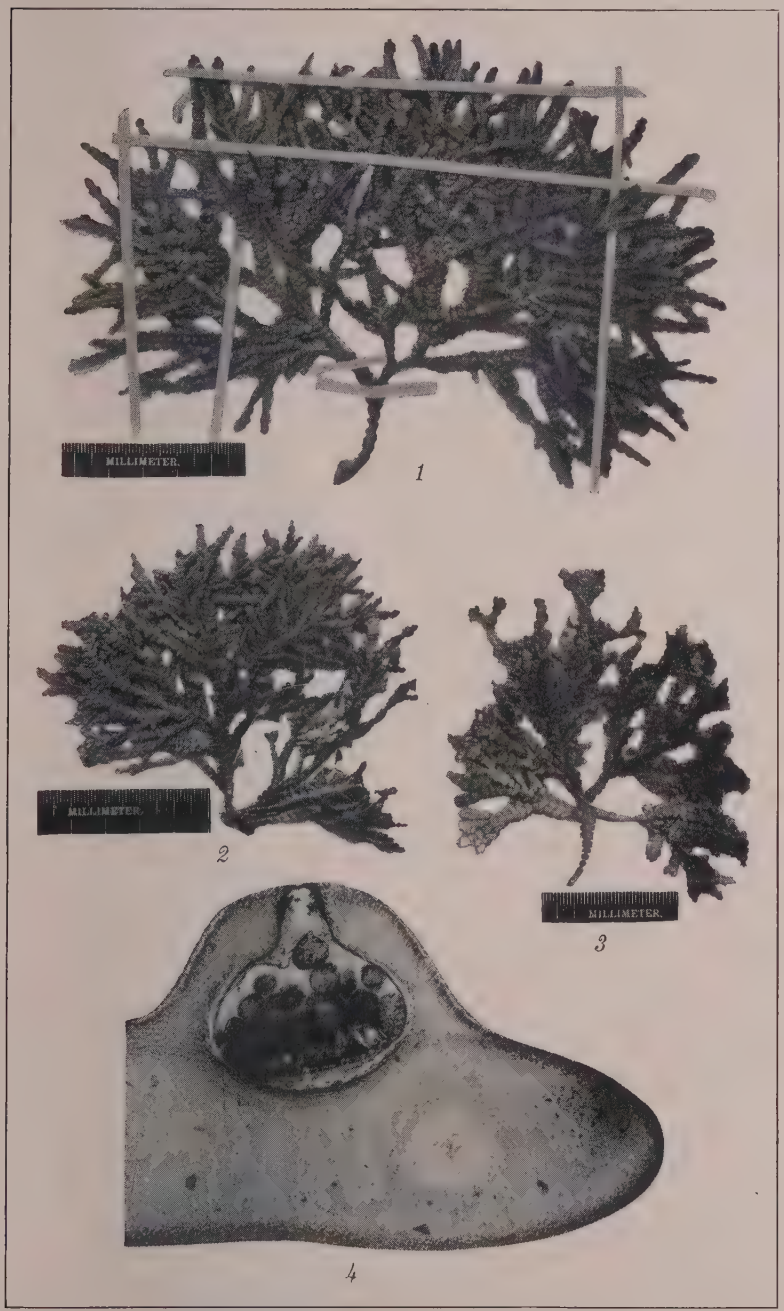

PLATE 6. CALLIARTHRON SETCHELLIAE MANZA.

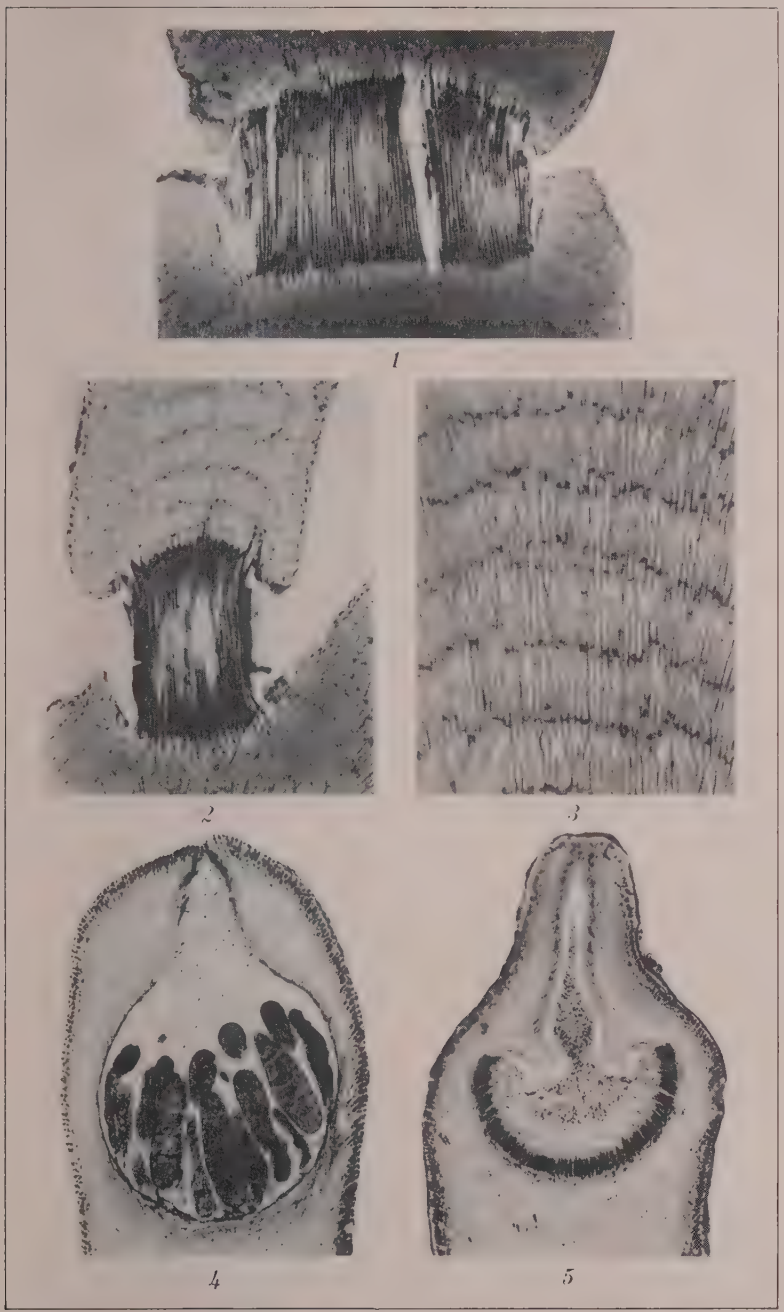

PLATE 7. CORALLINA (EUCORALLINA) OFFICINALIS LINNÆUS.

PLATE 8. DUTHIEA SETCHELLII MANZA.

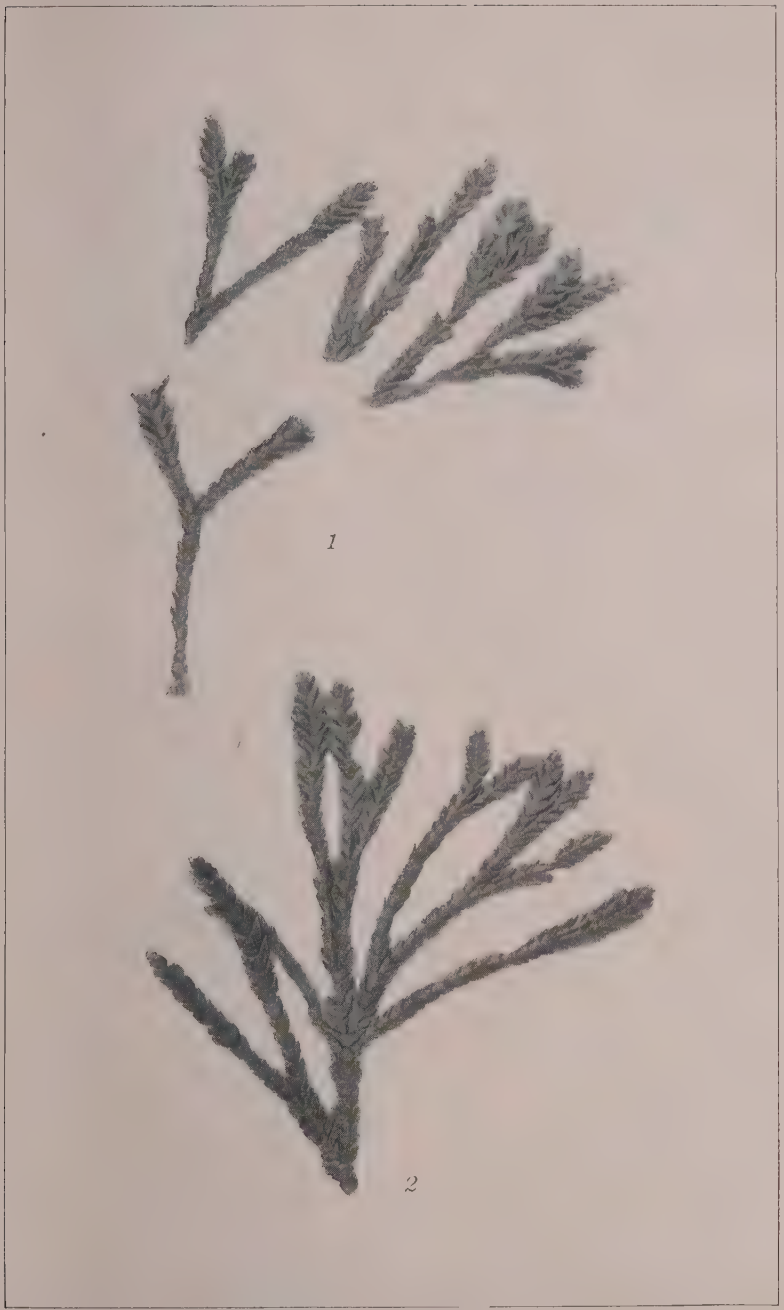

PLATE 9. CHEILOSPORUM SAGITTATUM (LAMX.) ARESCHOUG.

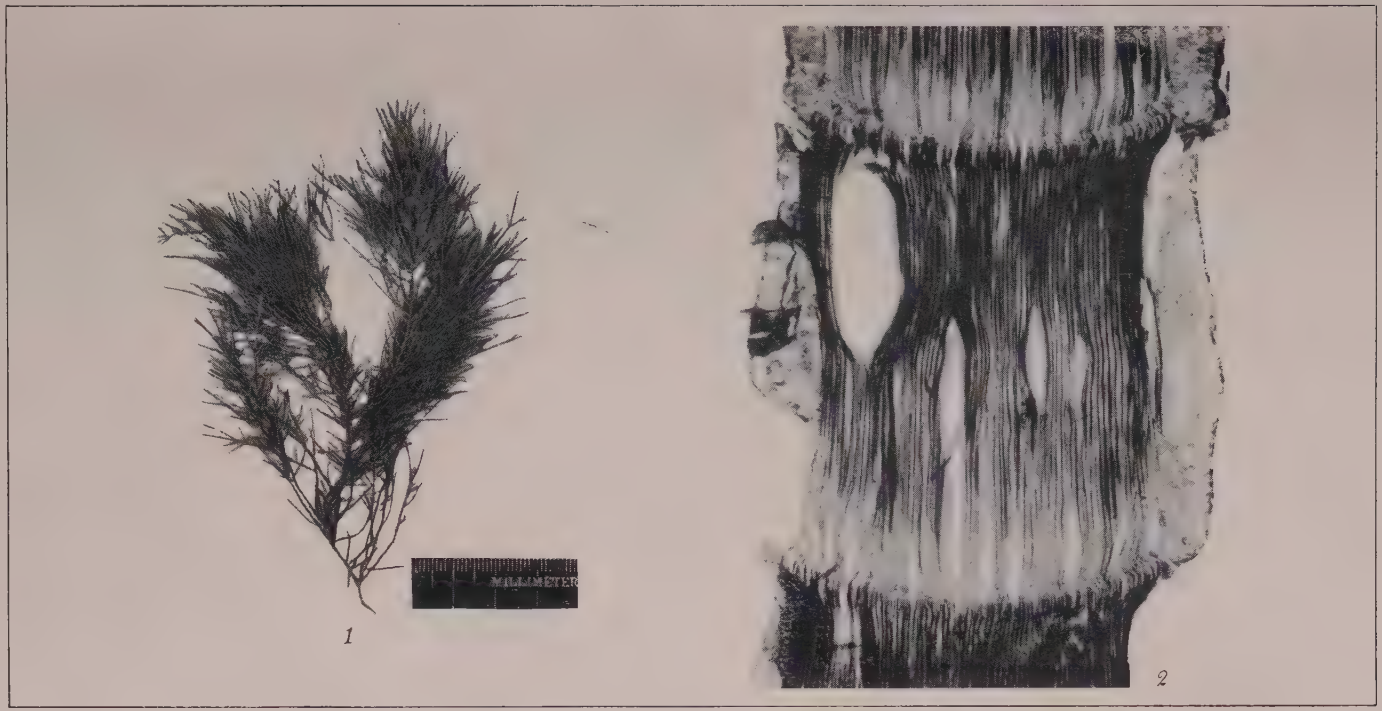

PLATE 10. LITHOTHRIX ASPERGILLUM GRAY.

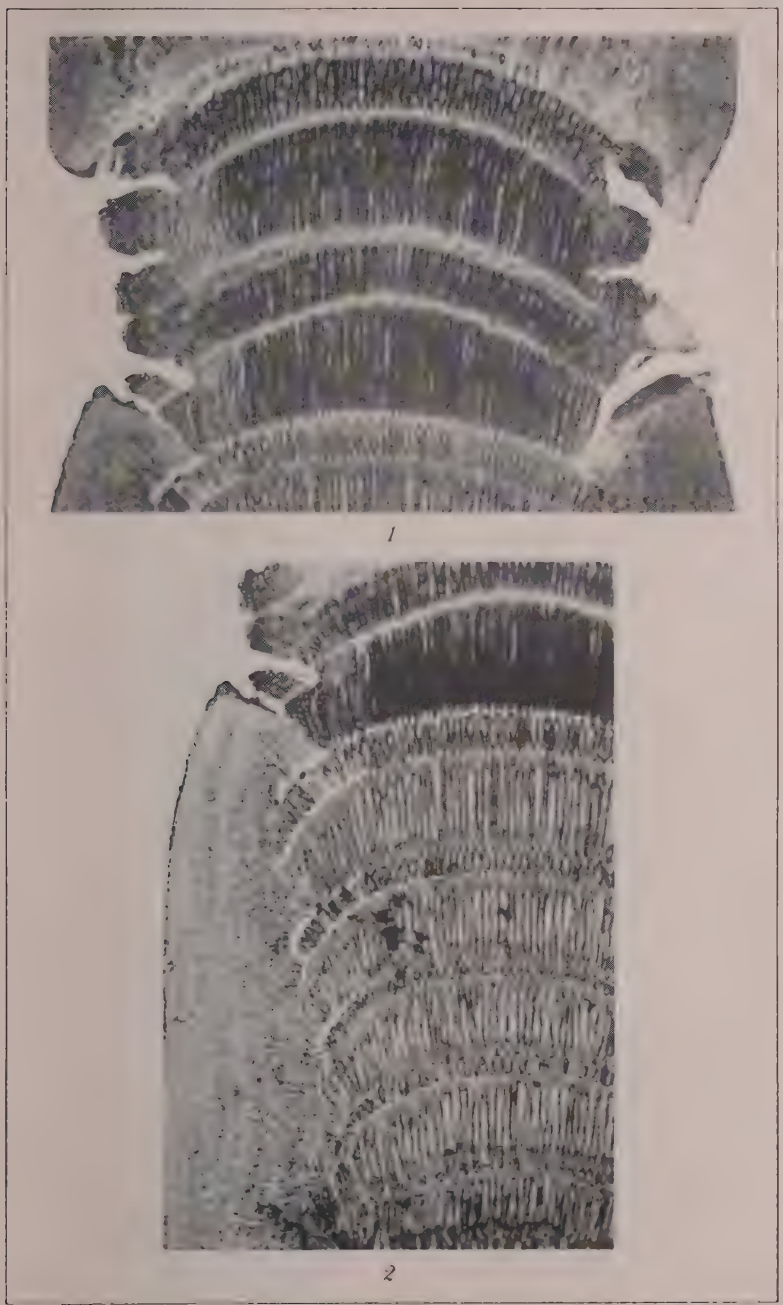

PLATE 11. AMPHIROA ANCEPS (LAMX.) DECNE.

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PLATE 12. BOSSEA PLUMOSA MANZA.

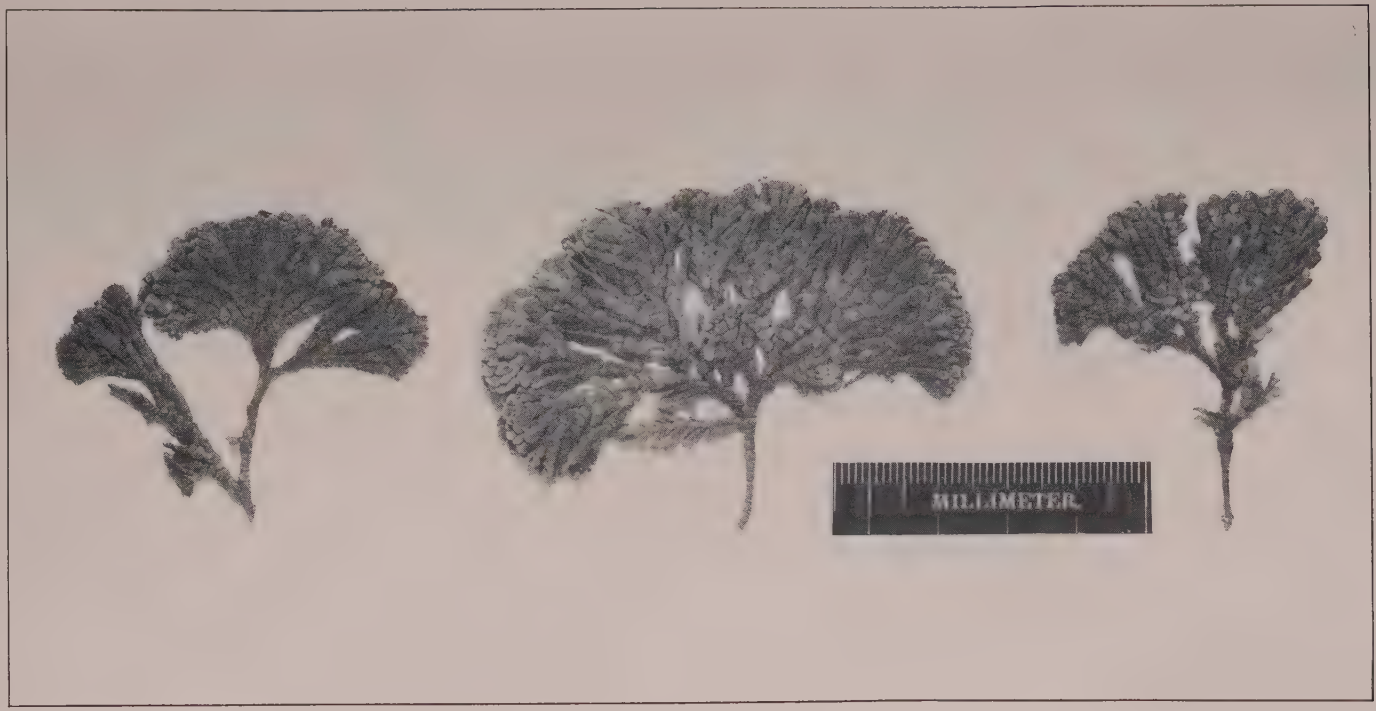

PLATE 13. BOSSEA CORYMBIFERA MANZA.

PLATE 14. BOSSEA FRONDIFERA MANZA.

PLATE 15. BOSSEA GARDNERI MANZA.

PLATE 16. BOSSEA INTERRUPTA MANZA.

PLATE 17. BOSSEA DICHOTOMA MANZA.

PLATE 18. PACHYARTHRON CRETACEUM MANZA.

PLATE 19. METAGONIOLITHON CHAROIDES WEBER VAN-BOSSE.

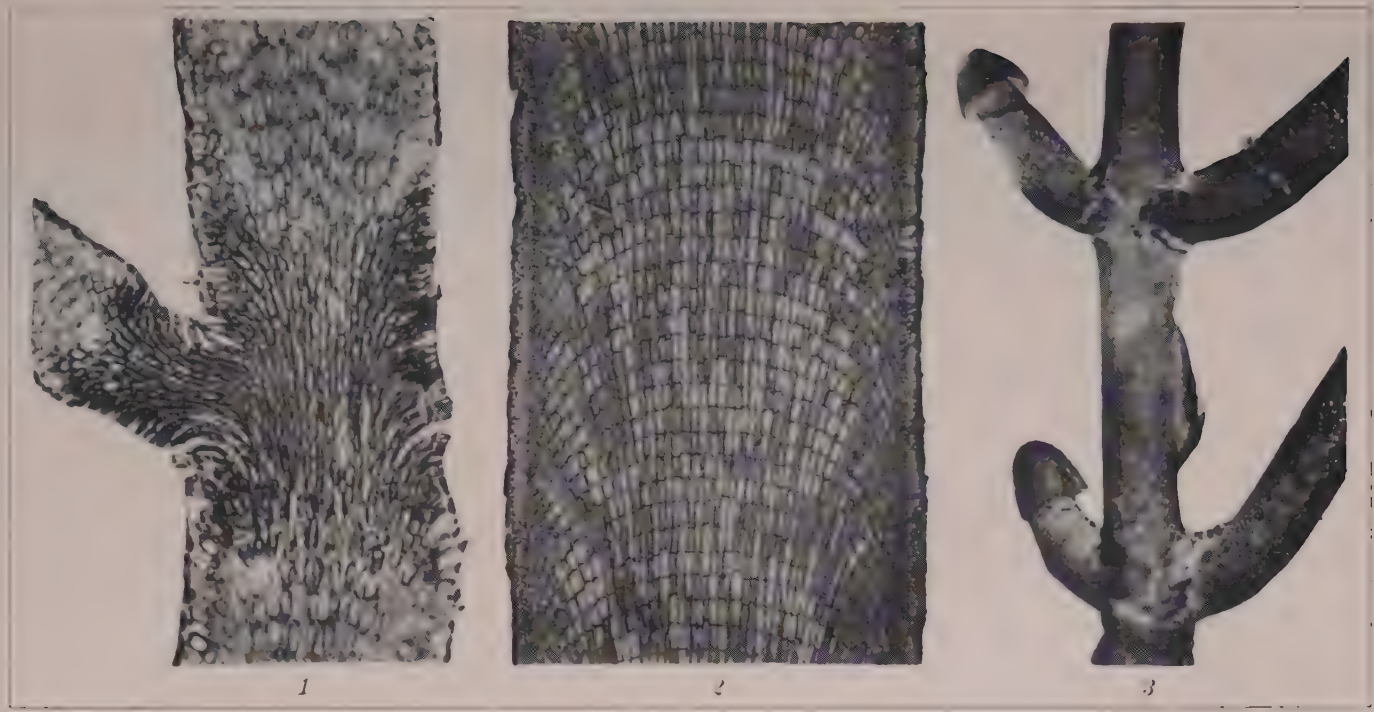

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PLATE 20. METAGONIOLITHON STELLIGERA WEBER VAN-BOSSE.

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